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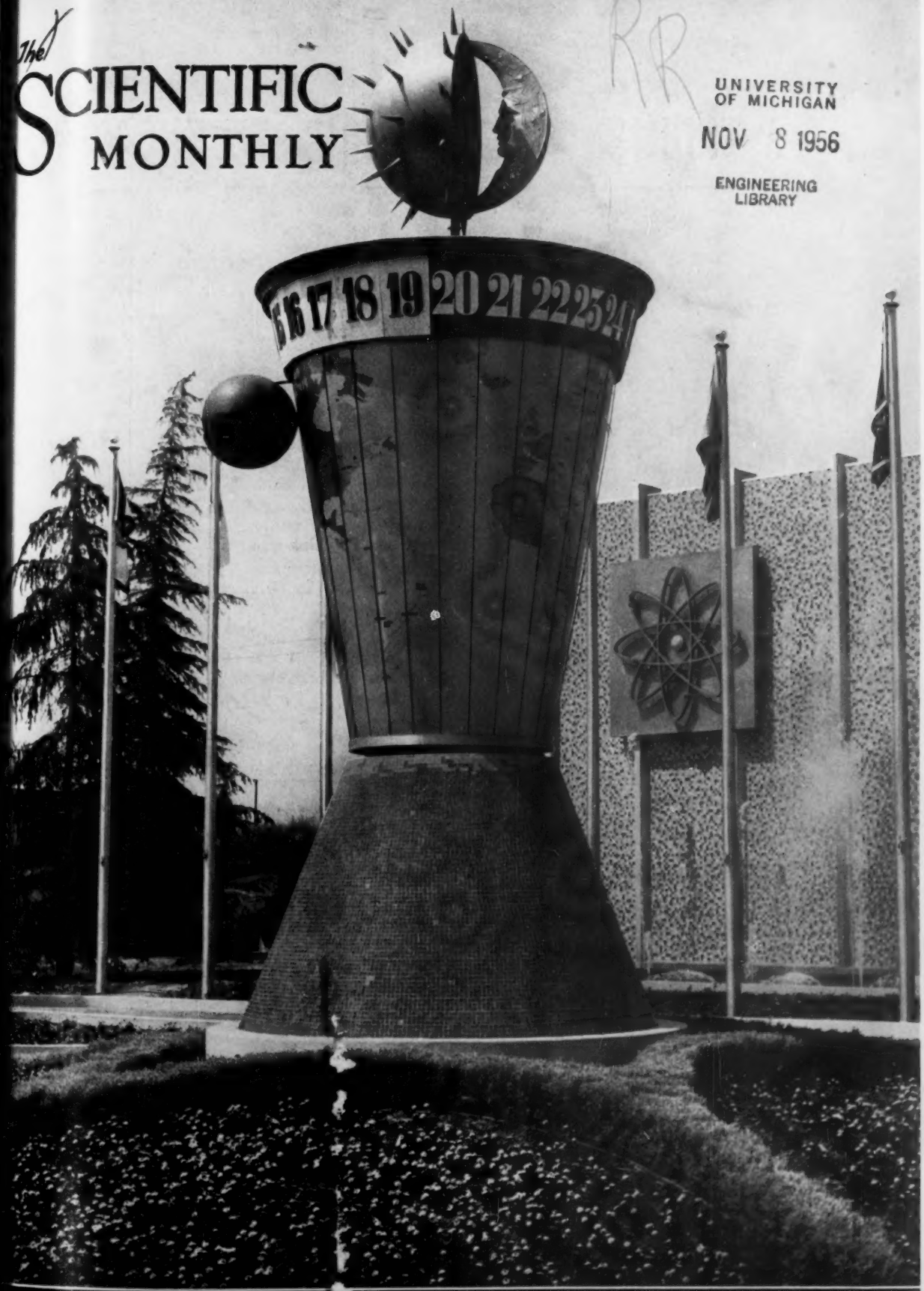
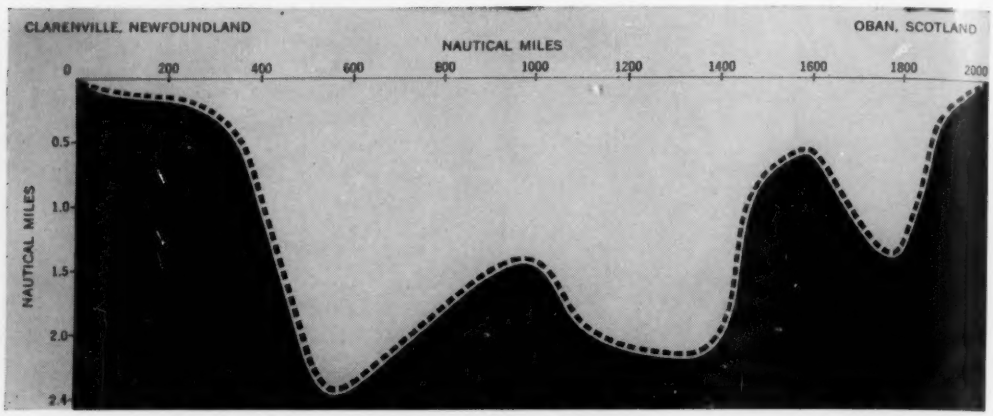


VOL. 83 NO. 5

NOVEMBER 1956

A TRIUMPH OF TELEPHONE TECHNOLOGY



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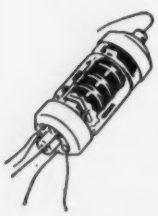

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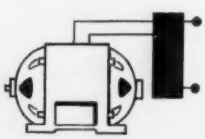

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[*Courtesy Robert W. Young, Huntington Park, California, see page 241*]

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Science and Technology

All inquiries concerning items listed here should be addressed to The Scientific Monthly, *Room 604, 11 W. 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).*

Light Pulsing Apparatus

A new light modulator delivers pulses of light in the microsecond range and modulated beams that are variable from direct current to video frequencies. A crystalline analog of a Kerr cell that is made up of a Z-cut plate of ammonium or potassium dihydrogen phosphate is situated between electrodes and allows light to pass in the same direction as the applied electric field. For normally incident collimated light, the unit has the properties of a polarization retardation plate, with the magnitude of retardation directly proportional to the applied voltage. A beam can be modulated in intensity in accordance with the voltage applied to frequencies beyond the video region when the crystal device is placed between polarizers. (Baird Associates, Inc., Dept. M1)

Proportional Counter Tube

Analyses for low-atomic-number elements is possible with a proportional counter tube that includes a 0.00025-in. thick Mylar film window that provides high transmission efficiency. The tube works without quench and utilizes a gas that is 90 percent argon and 10 percent methane. Gas leakage is slow enough to permit a flow rate of 0.1 cm^3/sec. The useful plateau voltage range is 1000 v. (General Electric Co., Dept. M2)

Dialyzer

A new dialyzer provides mechanical dialysis of a number of samples simultaneously in fixed volumes of dialyzate and buffer or by continuous flow. Agitation of buffer and specimen is accomplished by a revolving turntable that is tilted at an angle, and the speed of dialysis is controlled by varying this angle. For continuous-flow dialysis, a stainless-steel container with an overflow control receives and vents liquid from a circulating cooler or water tap. (Laboratory Glass and Instruments Corp., Dept. M3)

Polarecord

A line-operated polarecord employs single sheets to record polarograms of identical dimensions. The width of the paper is 250 mm, and the paper can be advanced at two speeds, requiring either 6 or 12 minutes for an entire run. The greatest sensitivity of the recorder is 1×10^{-10} amp/mm. (C. A. Brinkman and Co., Dept. M5)

Spectrometer

A scanning spectrometer is capable of detecting impurities to 1 part/10^9 and produces a first-order reciprocal linear dispersion of 16 A/mm at the exit slit, with a minimum resolution of 0.2 A. Variable-speed scanning in either direction is possible. (Jarrell-Ash Co., Dept. M6)

Measuring Aid

A recently developed serum-agar measuring aid, for photometric quantitation of serum-agar columns, indicates density and distance of leading edges, trailing edges, and zone widths of diffusing precipitin systems. (Analytical Instruments, Dept. M13)

Balance

An ultramicrobalance, for precise weighing of microgram quantities, has a sensitivity of 0.1 μg (or up to 0.001 μg on special order) and a load capacity that is 4 million times the sensitivity. The quartz-torsion balance can withstand shocks that would seriouly damage a knife-edge balance. Quartz beam and torsion fibers are fused into a single unit. This construction, it is said, makes possible positive duplication of weighings. The entire quartz system is gold-plated to aid in the dissipation of any static charge that might accumulate. Pan holders are designed to support platinum pans, capillary tubes, or suspended objects. Space for tares is also provided. Special mountings to dampen vibration for reproducible weighings are not required. (Microtech Services Co., Dept. M9)

Pressure Transducer

A new piezoelectric transducer employs sensitive elements of the lead zirconate formulations and provides free-field pressure-time traces for sound or shock waves. It covers a range of up to 1000 lb/$in.^2$ and flat frequency response (±2 db) from 1 to 80,000 cy/sec. Capacitance of the unit is 0.0025 μf, and its d-c resistance is maintained above 500 Mohm. The sensitivity of the instrument is stable over a temperature range of from −40 to 100°C. (Atlantic Research Corp., Dept. M20)

Laboratory-Animal Cage

Laboratory investigation of the excretion patterns of small animals that have been injected with C^{14}-labeled compounds is possible with a new metabolism cage. Toluene is used as a urine preservative in the collecting flask and serves as an indicator for the system. The air from the chamber is bubbled through an alkaline absorption column, from which the CO_2 may be recovered for radioassay. The central column is removable through a rubber sleeve for replacement, and a filling funnel and side arm makes possible the replacement of the absorbing solution, which is removed at the bottom of the tower. A trap in the floor of a feeder prevents the animals from pulling small crumbs into the cage. Temperature may be controlled with fans and moist towels under difficult weather conditions. A bank of three or four cages can utilize a single manostat set at about 10 mm-Hg below 1 atm. (Birsch Scientific Co., Dept. M16)

Automatic Cage Washer

The development of an animal cage washer that cleans up to 40 cages per hour has recently been announced. The automatic washer cleans two cages at one time in sizes up to 21½ by 14¾ by 14 in., or one cage may be cleaned in sizes up to a maximum of 21½ by 29½ by 14 in. Animal feeders and other laboratory equipment within these dimensions may also be cleaned in the machine. Closing the cabinet door starts the cleaning cycle, which has the following sequence; hot, recirculated cleaning-solution spray for 30 sec; hot-water rinse for 60 sec; and a drain-dry period of 90 sec. However, the wash operation is adjustable up to 150 sec, and the hot-rinse operation is adjustable up to 60 sec. Residual matter that is removed from cages and feeders is caught in a screen basket. Automatic controls maintain temperatures. (Ransohoff, Inc., Dept. M12)

Photometer

A microphotometer that measures from 20 $\mu\mu$lu to 20 lu and indicates percentage of transmission, density, and phototube current directly has been produced. Three light-scattering cells are furnished with the instrument. These include a square cell (path length, 2.4 cm) for use in density, transmission, absolute turbidity, and 90° measurements; a cylindrical cell for use at scattering angles from 0° to 147°; and a microcell assembly for use when the same continuous angular measurements on samples no larger than 2.5 cm^3 are made. Optical transmission from 10^{-9} to 100 percent is measurable. (American Instrument Co., Inc., Dept. M4)

Spectrophotofluorometer

Continuous activation of compounds is possible with a spectrophotofluorometer that measures resulting fluorescence throughout the visible and ultraviolet regions. Quantities of 0.01 to 1 μg/ml may be determined in quantitative assays of organic compounds that fluoresce. Only 1 ml of sample is required, and a range of 200 to 800 mμ is covered by an activating and a fluorescent monochromator. The unit consists of a xenon lamp, monochromators, ballast and control for the lamp, a photomultiplier and a microphotometer. (American Instrument Co., Inc., Dept. M7)

Surface-Quality Meter

A gloss, color, and reflectance meter has been devised that makes automatic and recorded measurements of gloss, haze, transmittance, reflectance, color, and other spectral values related to specific geometric conditions of illumination and view. Several different types of exposure heads may be used with the instrument. These include reflectometers, gloss heads, a transomittometer, a goniophotometer, and a haze-meter. A typical exposure head contains a light source, a comparison photocell, and a test photocell. The sample under examination is inserted in the head near the test photocell and is illuminated by light from the standard source, focused on it by lenses and mirrors. This illuminating light is reflected to the test cell. The exposure head is connected to the photometric unit. A zero adjustment compensates for stray light within the exposure head and is used to produce a zero reading on the dial when there is no sample in the sample area. The recorder can be made to record the values printed on the standard supplied. (Gardner Laboratory, Inc., Dept. M23)

Computing System

Problem solutions are performed up to 50 times per second by an analog computing system that allows an operator to change problem parameters and observe instantaneously and continuously the resulting changes in problem solutions. Applications include the study of alternative-system configurations, optimizing the parameters of a defined system, solution of boundary-value problems, and trial-and-error design of any given physical system. The system consists of a master generator and two basic computing units that are capable of solving problems up to the 12th order. The basic computing units contain six summing amplifiers, six summing integrators, and 24 coefficient potentiometers. The master generator produces a train of control pulses and derives from these pulses a synchronized set of control signals. (GPS Instrument Co., Inc., Dept. M22)

Neutron Survey Meter

Measurement of thermal and fast neutron fluxes of from 10 to $10^4/cm^2$ sec can be achieved with a portable neutron meter. The instrument contains two boron trifluoride proportional counters, one of which measures thermal neutrons. The other is sensitive only to neutrons with energies above the cadmium resonance at 0.176 ev. No response is given in the pure gamma flux of up to 100/mr hr. Fluxes of less than 10 neutron/cm^2 sec can be estimated. The meter scale is logarithmic and covers a range of from 10 to 10^4 neutron/cm^2 sec. (Nuclear Instrument and Chemical Corp., Dept. M19)

Aquatrator

Karl Fisher reagent is utilized by an aquatrator for rapid determinations of moisture contents from 0.005 to 100 percent in liquids and solids. The burettes have a capacity of 25 ml with a reservoir of 1000 ml, and the sample container has a capacity of 100 ml. Samples are weighed in a sample beaker with a magnetic stirring rod. An excess of the reagent is back-titrated with a standard solution of water and methanol. A double platinum electrode gives immediate readings of the approaching end-point, which is indicated on a meter. (Precision Scientific Co., Dept M8)

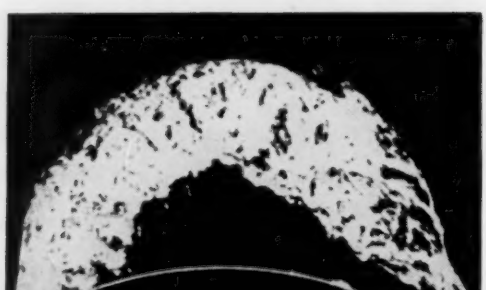
Cork-boring Machine

A power cork-borer has been designed that produces accurately bored, smooth holes in rubber and cork stoppers for laboratory glassware. The instrument is essentially a condensed drill press with vertical motion inverted. The cutting tubes are driven at 800 rev/min. (E. H. Sargent and Co., Dept. M18)

ON TELEVISION

NOVEMBER 19

"Our Mr. Sun"



Pictures of natural phenomena figure prominently in "Our Mr. Sun," like this High Altitude Observatory movie of an explosion on the sun.

The first in a series of TV shows about science, sponsored by the

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"Our Mr. Sun" is a full-hour film in color, deals with solar physics, solar astronomy and the uses of solar energy. Its accuracy and authenticity are assured by a panel of the world's leading scientists in solar studies, including Dr. Farrington Daniels, Dr. Armin Deutsch, Dr. Donald Menzel, Dr. Walter Orr Roberts and Dr. Otto Struve. Produced and directed by the Academy Award-winning director Frank Capra; animated drawings by UPA Pictures, Inc.

Tune in this special science telecast on the **CBS-TV** **Network, 10 to 11 P.M., E.S.T., November 19, 1956.** *Check local listings for time and station.*

THE
SCIENTIFIC MONTHLY

NOVEMBER 1956

Seismology and the U.S. IGY Program

A. P. CRARY

After approximately 9 years in exploration seismology, Mr. Crary joined the staff of the Air Force Cambridge Research Center, as research scientist in geophysics, and he is still attached to this organization, although at present he is on loan to the International Geophysical Year offices in Washington, D.C. During the last 4 years with the Air Force, Mr. Crary worked with the arctic ice island program, and in the IGY he is concerned with the antarctic operations. Mr. Crary received his training at St. Lawrence College and Lehigh University.

SEISMOLOGY is the study of elastic waves, or vibrations, the origin of these vibrations, and the manner of their propagation in the heterogeneous material of the earth. The subject is quite broad and includes many related subjects, the majority falling into four categories: (i) the study of earthquakes, (ii) the study of the earth through the manner of earthquake vibration propagation, (iii) the study of the earth's outer crust through the use of artificial explosions, and (iv) the study of the vibration of the earth brought about by the interaction of the atmosphere, hydrosphere, and lithosphere. It is along these general lines that we can discuss, first, the progress of seismology today, and second, the U.S. International Geophysical Year approach to seismological problems.

Earthquakes

Foremost in importance is the study of earthquakes and their effect on the community. How far has seismology progressed in regard to such problems as outlining the regional and local areas that are most vulnerable to earthquake damage, determining optimum construction to minimize earthquake damage to structures, and last, predicting or forecasting the times and places of future earthquakes? Seismology has provided answers to all these questions with some degree of success. The number of standard seismograph "listening" stations in operation throughout the world is now about 300, and many additional pieces of specialized equipment are located in areas of frequent earthquakes. The geographic location of major earthquakes—their epicenters—can be ascertained to a high degree of accuracy even though the site may be in an oceanic or sparsely populated area.

Sites of minor earthquakes, however, can be found only if their epicenters are near the stations, and the 300 "listening" stations are quite naturally concentrated in areas of known activity and of population centers. Sufficient evidence has been accumulated to outline the general areas of earthquake activity. The earthquake engineer can also tell, through special structural stress studies but mainly through close inspection of damages, the optimum structural design for particular areas as well as the most favorable construction sites.

The problem of forecasting earthquakes has been attacked through the study of the accumulated strains in the crustal material of the earth. Advances have been made in the last few years, mainly at California Institute of Technology, through two types of approach. In one, the accumulated sum of earthquake energy in local regions or over broad areas is calculated by using an empirical relationship between seismic wave energies and earthquake energies. The characteristics of change of the accumulated energies are studied with time, and a simple mathematical relationship is found which

can be extended into the future (Fig. 1). The deviation of this theoretical curve from that of the known energy release is a measure of the accumulated energy available for earthquake production. Various kinds of specialized equipment are also being built at present in which the strain can be measured directly. The accumulation and release of the strain can be characterized directly for the particular region.

From another viewpoint, the structural geologists and geophysicists are interested in details of earthquakes as an insight into the tectonic activity or the deformation of the earth's surface. In the fashioning of the earth's outer features, movements may be accompanied by fracturing of crusting material, and it is this fracturing that initiates the seismic energy. Through study of the details of seismic recordings, the initial direction, magnitudes, and other characteristics of the fracturing movements can be determined to give a better understanding of the processes of mountain making, especially folding of the crust, that are continually at work. It is of interest in this regard to know the depths at which this fracturing takes place, and this can also be determined from the study of the seismogram recordings.

The Earth

The second phase of seismological study puts the earthquake vibration to scientific use. The tremendous energies released during a large earthquake spread through the earth, refracting and reflecting according to their velocity and according to the variation in density of the earth's material. By the accumulation of travel times and by the character of the vibrations at various distances from the area of the shock, information about the velocities

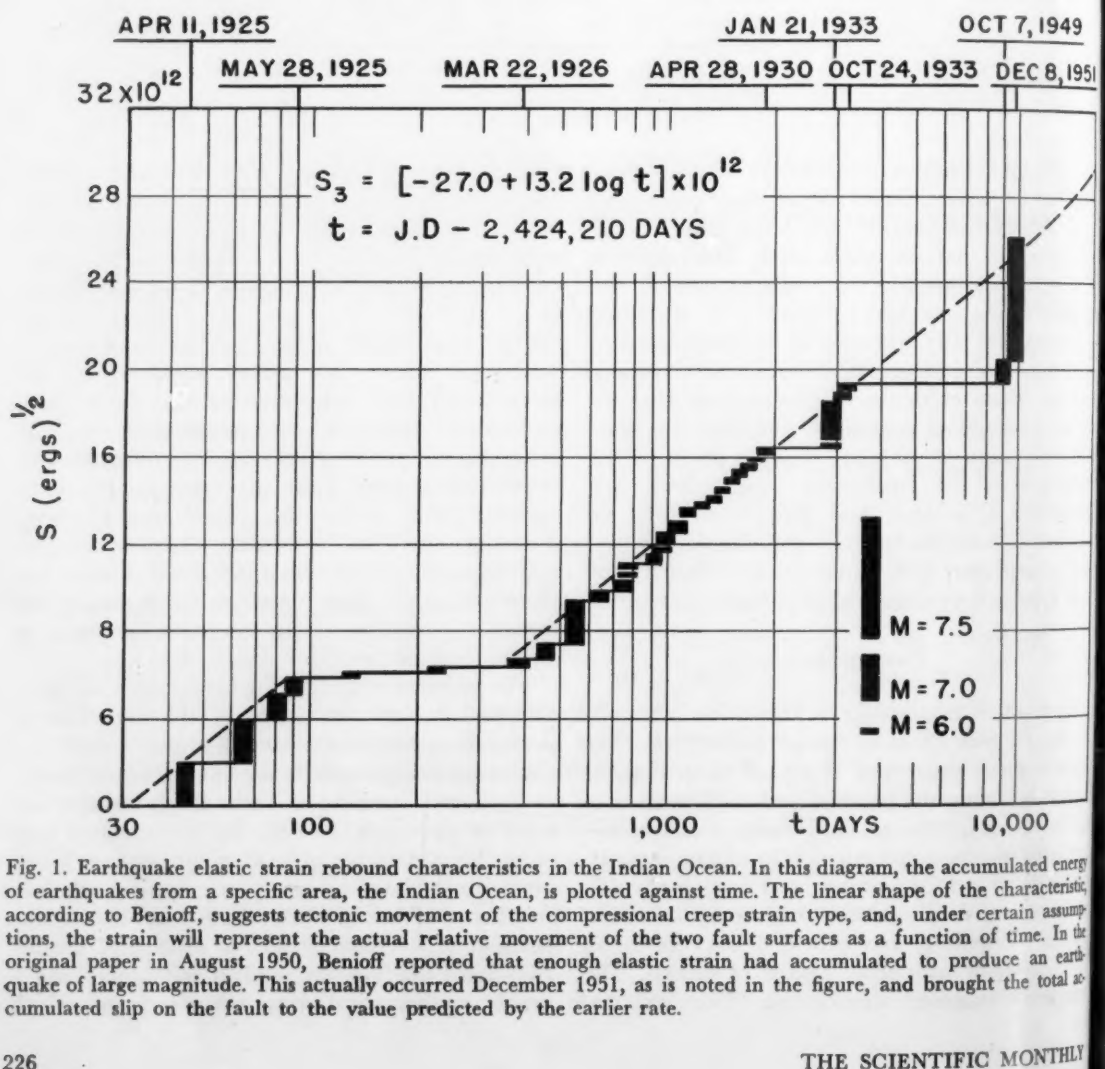

Fig. 1. Earthquake elastic strain rebound characteristics in the Indian Ocean. In this diagram, the accumulated energy of earthquakes from a specific area, the Indian Ocean, is plotted against time. The linear shape of the characteristic, according to Benioff, suggests tectonic movement of the compressional creep strain type, and, under certain assumptions, the strain will represent the actual relative movement of the two fault surfaces as a function of time. In the original paper in August 1950, Benioff reported that enough elastic strain had accumulated to produce an earthquake of large magnitude. This actually occurred December 1951, as is noted in the figure, and brought the total accumulated slip on the fault to the value predicted by the earlier rate.

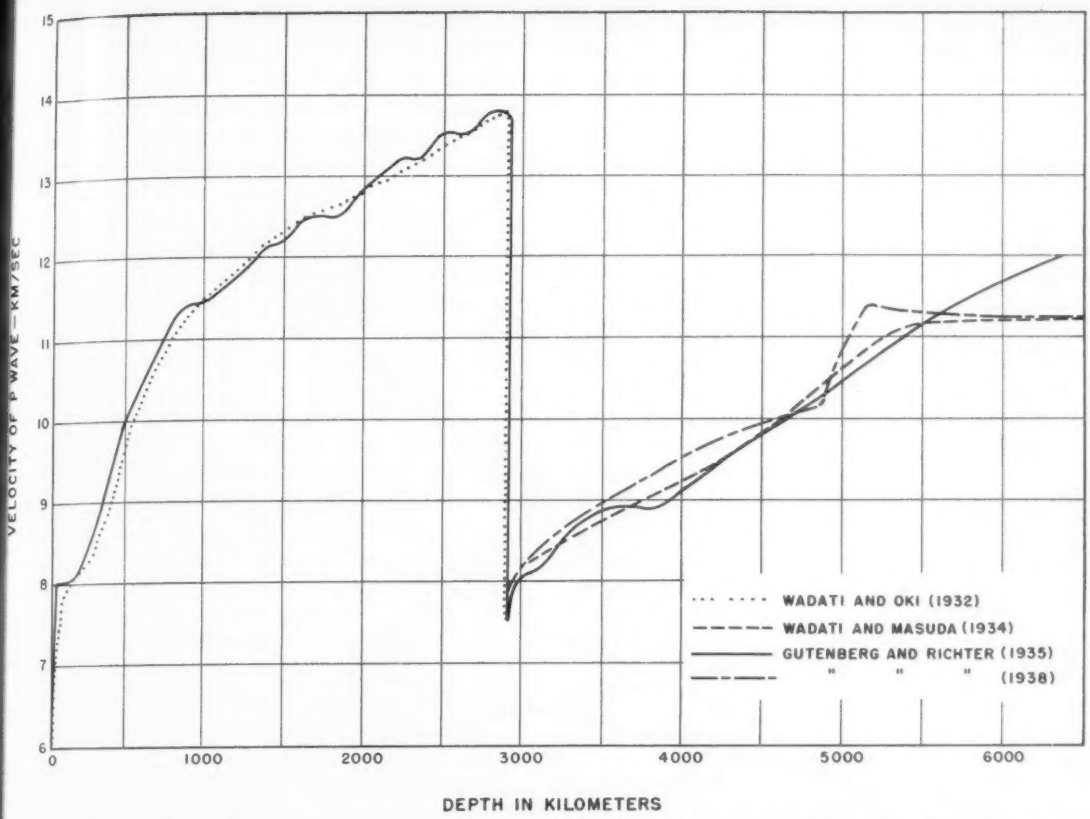

Fig. 2. Use of earthquakes in the study of the interior of the earth. The graph shown here of the variations of the *P*-wave velocity with depth below the surface was determined by various researchers from study of the travel times of earthquakes to various recording sites. The boundary of the earth's core, supposedly in liquid or semiliquid state, is very evident.

and about the densities of the crust and the interior of the earth has been found (Fig. 2). Indeed, it has been almost wholly due to the efforts of seismologists that we now have an understanding of the physical properties of the various layers or shells that form the earth's interior. This understanding is also a prerequisite to the study of earthquakes, for, until full knowledge of the earth's structure is obtained, the character of the seismograms cannot be fully utilized to the extent that details of the ground motion at the site of the earthquake can be found.

Earthquakes occur in their own time and place. Except for small aftershocks which nearly always follow in the wake of major earthquakes, the student of the earth is limited by the number of earthquakes and by the areas in which they occur for details of the outer crust. Hence, these details can be best determined through use of artificial vibration releases most easily obtained in large energy by explosives, which can be located as desired both in time and space (Fig. 3). To the extent of energies released, exploration can be made of local areas of the crust to depths usually within 30 or 40 miles. This information forms a supplement to that obtained during earthquake energy releases, where logistic considerations limit the type of recording equipment and where part of the results must be first used to determine the time and place of the earthquake. Local studies are best exemplified commercially by seismic oil exploration and by similar types of operations that are carried out to obtain depths of water over the oceans or of ice over icecaps.

Atmospheric Disturbances

Our last category of seismology involves a controversial subject but one quite familiar to all earthquake seismologists—microseisms. Microseisms represent the main source of the high background noise found in earthquake recordings. They are the gradually appearing and disappearing rumblings of background vibrations of the earth, and they are

detectable on the sensitive earthquake recording units. Microseisms are dissimilar to earthquakes, for the continual earth motion contains no sudden bursts of energy. For years a mystery, they have in the last 15 or 20 years been studied at considerable length and found to be caused by anomalies of atmospheric circulation. Hence, this subject takes on a new and important aspect, the study of the atmospheric disturbances. The seismologists have attempted to utilize microseisms in determining hurricane centers, frontal atmospheric wave passages, and other centers of disturbance (Fig. 4).

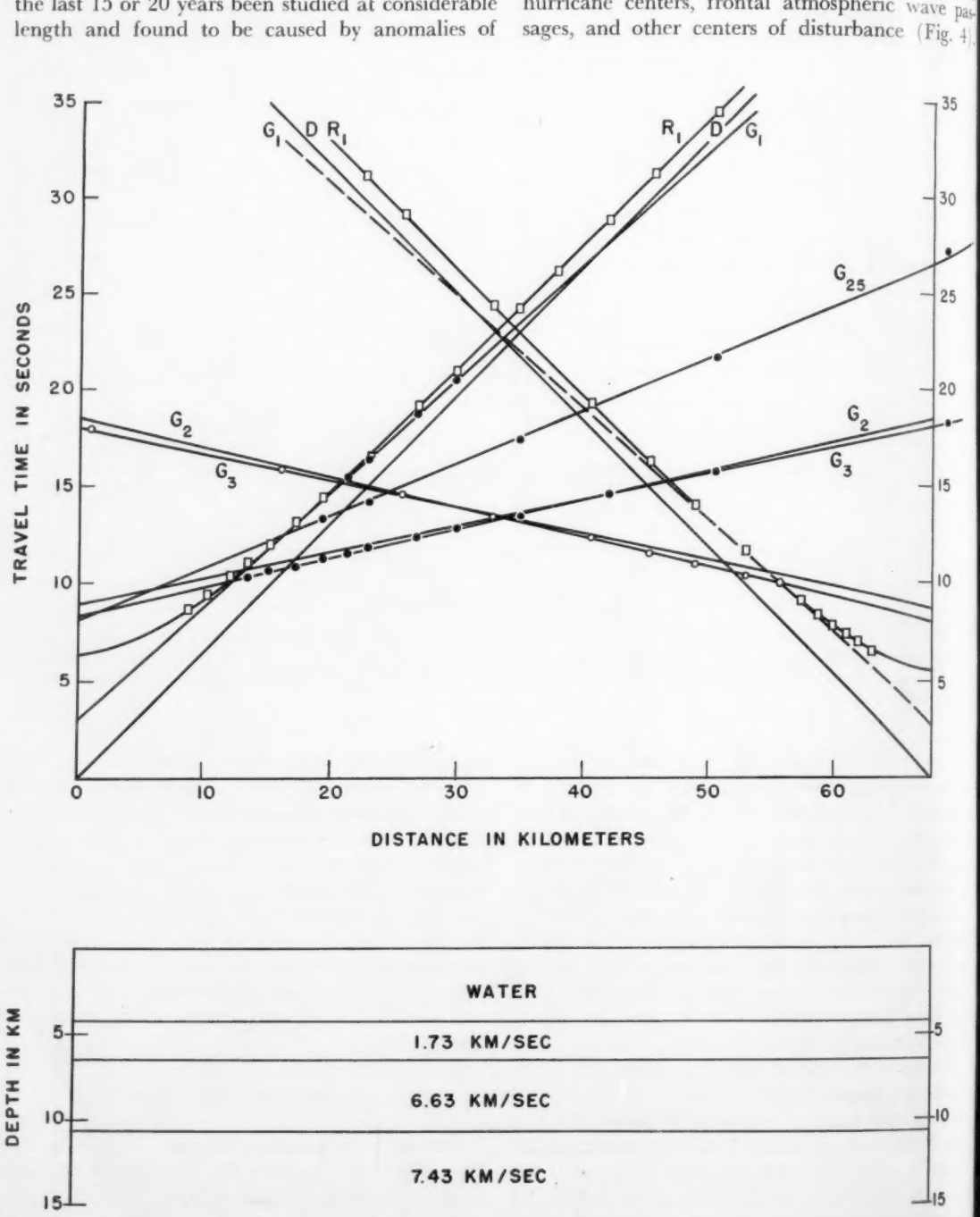

Fig. 3. Crustal studies at sea by use of artificial explosions. The upper figure is the time-distance graph in which seismic wave arrival times obtained at various distances between two shot locations (at 0 and 70 kilometers) are plotted. The slopes of the lines connecting the points determine the apparent velocities beneath the surface. The lower figure shows the final results of the experiment, in which three distinct layers were found beneath the ocean floor.

This difficult and exacting study still continues, and the present solution appears to be far from satisfactory. Awaited mainly is better knowledge of violent atmospheric phenomena over the oceans, for it is through the medium of the oceans that the majority of microseismic energy is transmitted from the air to the earth.

A characteristic of seismic vibrations that distinguishes the various categories is the frequency or tone of the vibrations. A continued loss by reflection of the shorter wavelengths—those approaching the areal extent of discontinuity surfaces—gives a preference at long distances to the lower frequencies. Hence, except for special types of waves, the strength of the source and the duration of travel of vibrations generally determines the frequency spectrum recorded. For artificial waves, the frequencies usually vary from a few hundred cycles per second to a large fraction of a cycle per second; for microseisms, the frequencies are generally from 1 to 0.1 cycle per second, and for earthquakes from about 1 to 0.002 cycle per second. In the latter category, it is easier to think of this characteristic in terms of wave period—from 1 second to as much as 8 minutes per cycle. Normal earth movements caused by footsteps or the passing automobiles are noticed as high frequency vibrations locally; hence, they are serious handicaps to such operations as oil prospecting. However, to the standard earthquake instrument of long periods, these local noises are of less consequence.

A brief description may be made of another vibration characteristic. Instead of a single type wave motion that has in a certain medium a definite velocity, such as we are accustomed to in sound in the air, there are two main types of vibrations, each having in a given medium and under a given circumstance a characteristic velocity. These are defined by the direction of travel. In the *P*, or compressional wave, particle motion is parallel to direction of travel, while in the *S*, or transverse wave, particle motion is at right angles to the direction of travel. The *P* wave can be originated by compression such as an explosion or a weight dropping. The *S* wave is activated by a shear or tearing motion such as is found in earthquakes. The latter is more difficult to form by artificial means. The *S* transverse wave cannot be transmitted through a liquid material. At a boundary surface, especially noted at the surface of the earth, other types of waves are produced that vary in velocity with frequency. These are the main destructive waves in earthquakes, and they attain quite large amplitudes. At boundaries separating materials of differing characteristics, the incoming waves are reflected back and refracted onward in varying percentages, also separated into wave types. The final vibrations recorded on the seismographs are therefore extremely complicated.

IGY Program

In 1951 the executive board of the International Council of Scientific Unions (ICSU) appointed a special international committee to supervise the planning and world-wide cooperation of a program of geophysical observations, called the Special Committee for the International Geophysical Year (CSAGI). National committees have now been established in more than 45 nations to administer this program. In the United States, panels have been set up for each of 13 scientific disciplines to plan the details of the various operations, which are to cover the period July 1957–January 1959. The panel for seismological work consists of leading seismologists of the United States. It was originally under the leadership of James B. Macelwane. Following his untimely death early in 1956, this responsibility was taken over by Perry Byerly. The review of the proposed projects can best be outlined by reference to the four classifications mentioned previously.

One of the obvious recommendations of international interest in regard to seismology was the increase in the number of seismographic stations throughout the world, with the emphasis on those vast areas such as the Pacific Ocean, the Antarctic Continent, and the Arctic Ocean basin, where such installations are either very scarce or nonexistent. To date, a total of more than 20 new earthquake recording stations are planned during the IGY, and it is expected that others will eventually be added. Nine of these stations are to be installed by the United States; three in the equatorial Pacific Ocean, two in the arctic areas, and four in Antarctica.

This increase in the number of station seismographs contributes both to the more detailed study of earthquakes in the vast unpopulated or little populated areas and to the study from earthquake waves of the earth's composition. This will be true both of the outer crust of the earth, which is not at all uniform throughout the world, and of the earth's interior through increase of data available from major earthquakes.

A direct contribution to the study of earthquake characteristics will be made by the installation of two linear strain seismographs by California Institute of Technology. These installations will be made in the Andes Mountain region of South America, giving information on the manner whereby crustal strain is built up and released as

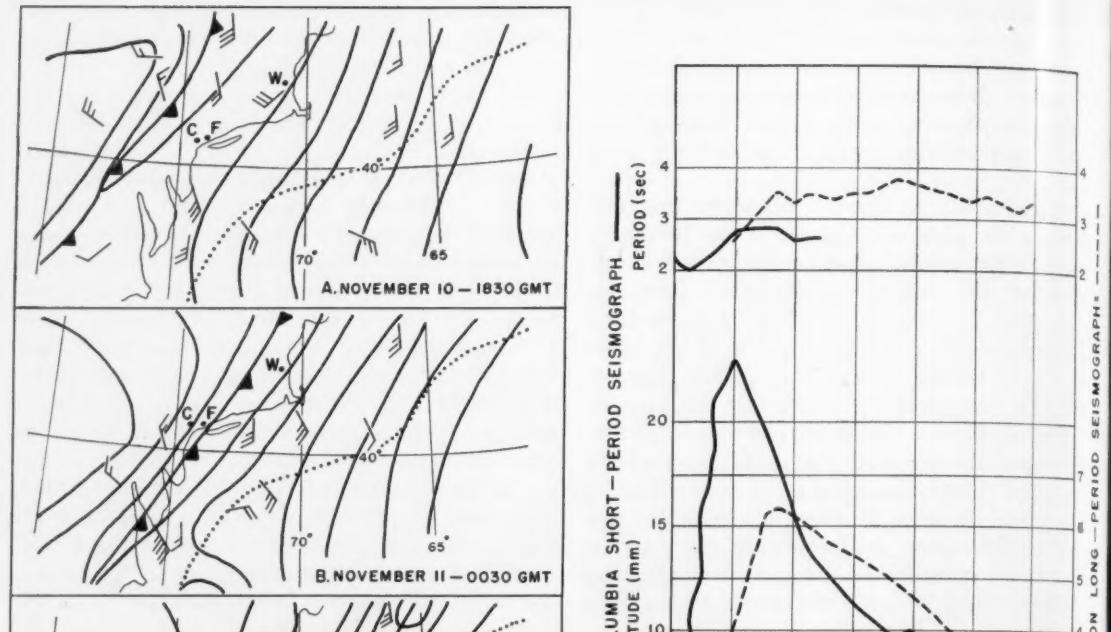

Fig. 4. Microseismic activity associated with a cold front. The three surface weather maps on the left show a cold front moving eastward across the United States Atlantic Coast. It is noted that the microseismic activity, as seen on the graph at the right, does not reach its peak until the cold front is over the ocean, and that it dies out as the front moves into deeper water. Other types of microseisms, associated with hurricanes, show maximum intensity when the disturbance is over the deep waters of the ocean.

earthquakes in this mountain range. Hence, it will be a beginning to understanding and comparison on a world-wide basis.

Studies of the characteristic velocities and of the densities of the interior of the earth will be augmented during the IGY, not only by the additional stations planned, but also by special equipment to be located at existing stations. The *Lg* wave is a short-period transverse vibration that was found by observers at Lamont Geological Observatory of Columbia University a few years ago. These waves are transmitted only over the type of outer crust associated with continents or continental blocks. Hence the geographic distribution of these continental-type crusts can be outlined by the study of earthquake records of stations where instruments are tuned to the frequency of the *Lg* wave. It is planned to make three more of these units available during the IGY, with locations at Trinidad, British West Indies, at Huancayo, Peru, and at one of the antarctic stations.

In recent years instrumentation has been perfected which will respond to earthquake waves having vibrational periods up to 500 seconds. To date, seismograms from these long-period instruments of two earthquakes have shown waves of this long period. Such surface waves, by virtue of their extremely long wavelengths, penetrate deep into the earth and may be considered as resulting from free earth vibrations. Ten of these long-period instruments are being built at Lamont Geological Observatory, and it is expected that these will be installed for the IGY at permanent seismograph station sites: Honolulu, Territory of

Hawaii; Santiago, Chile; Uppsala, Sweden; Lwiro, Belgian Congo; Hong Kong; Trinidad, British West Indies; India, Japan, and two other sites not as yet determined.

Microseismic knowledge will be vastly improved during the IGY, partly because of the increase in number of seismograph stations throughout the world, but mainly by the larger networks of meteorological and oceanographic observation stations. An increased effort will also be made to report periodically on an international basis the microseismic disturbances present on all earthquake station seismograms. Microseisms in the Pacific and antarctic areas can be studied for the first time with the advent of networks of seismic, meteorological, and oceanographic recording sites.

A large IGY program will also be undertaken in the third classification mentioned here, the study of the outermost earth's crust by artificially created explosions. Five projects are planned in this regard. Two of these are in exploration of the upper crustal material under the Atlantic and Pacific oceans. Seismic refractions and reflections, giving sediment thickness and crustal layering velocities, will be made on north-south traverses in both the Atlantic and Pacific deep basins. These will be done by Lamont Geological Observatory and Scripps Oceanographic Institution. In the Atlantic Ocean, measurements will be made on a traverse running almost the full length of the western and eastern basins. In the Pacific, the work will be concentrated in the Southern Hemisphere between the equator and 20 degrees south latitude, and from 160 degrees west longitude to the west coast of South America.

Another area in which similar detailed studies will be made is along the transition zone between the deep ocean basin and the continental region off the eastern coast of the United States. These studies will be made by the University of Wisconsin. Studies of continental crustal depths will be made in the Andes section of South America. The relation of these depths to elevations of the mountain areas will be a continuation of similar measurements made in the Rocky Mountain region. This program will be undertaken by the department of terrestrial magnetism of the Carnegie Institution of Washington.

The final program of the study of the earth's surface structure deals with the unique Antarctic Continent. On oversnow traverses across several thousand miles of inland ice, seismic reflection studies will give information on the thickness of the ice cover. A special effort will be made also along these traverse areas to obtain the velocity variations in the snow and ice with depth. This should result in information on the rate of snow and firn compaction near the surface and on temperatures in the interior of the glaciers.

To carry out this IGY seismological program, an intense effort is under way by leading universities with large seismological interests, by the U.S. Coast and Geodetic Survey, the department of terrestrial magnetism of the Carnegie Institution of Washington, and other agencies to build the vast quantity of instruments that will be needed and to recruit the seismologists who will carry out the worldwide observations. It is hoped that the increased impetus of the IGY undertaking will lead to expanded permanent facilities throughout the world and expanded interests in the studies of the structure of the earth, earthquakes, and microseisms.

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On Going Berserk: a Neurochemical Inquiry

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BERSERK was a mighty hero in Norse mythology. Legend states that he was the grandson of the mythical eight-handed Starkadder. He was renowned for his consummate bravery and for the fury of his attack in battle. He had twelve sons who were his equals in courage. He never fought in armor but in his *ber sark,* which means "bearskin" in the Nordic languages. Thus the term *berserk* became synonymous with reckless courage. During the Saga time (*1*) in Iceland and in the Scandinavian countries (A.D. 870–1030), and for some time prior to that period of careful historical recording, the Berserks, apparently bearing the same name as the legendary warrior, arose as a predatory group of brawlers and killers who disrupted the peace of the Viking community repeatedly. Today in the United States we would probably use such slang terms as *mobsters* and *hoodlums* in classifying them.

There is a fascinating theory that *Berserksgang,* or the act of "going berserk," which was the hallmark of the discordant behavior of the Berserks, may not have been a psychogenically determined habit pattern, but may rather have been the result of eating toxic mushrooms. This idea, fantastic though it may appear at first glance, has won general acceptance among Scandinavian scholars, according to Larsen (*2*). It is the purpose of this article (*3*) to review this theory in the light of present-day studies on hallucinogenic drugs that have chemical similarities to mescaline and lysergic acid diethylamide (LSD-25) and that are capable of producing model psychoses.

Mushroom Eating

Certain members of the vast botanical family of mushrooms have been among the "phantastica" most widely used to produce temporary psychoses throughout history. Among these are the *Amanita muscaria* and *Amanita pantherina* of Eurasia. The *muscaria* species (*4*) is the more common. These two species are distinct from those species of the genus *Amanita* which kill the eater (*phalloides, verna,* and *virosa*), and which contain a deadly hemolysin (*5*).

The *muscaria* fungus is commonly known as fly agaric. Albertus Magnus (*6*) noted before A.D. 1256 that when it was freshly cut and placed in a dish of milk or water it killed flies (*Musca*) when they ingested its juice, and Linnaeus reported that it had been advocated for killing bedbugs (*7*). It has long been used orgiastically by Siberian tribes of the Kamchatka Peninsula. The first European to describe the practice was von Strahlenberg in 1730 (*8*). Prodigious feats of physical strength are reported to have been accomplished under its influence. Vanderlip wrote (*9*), "Curiously enough, after recovering from one of these debauches, they claim that all the antics performed were by command of the mushroom." The myths of the Koryaks contain the belief, which is held to this day, that a person affected with fly agaric is guided by the spirits of the Wapaq that live in the mushroom. If an old man should eat agaric and the Wapaq within the agaric should whisper, "You have just been born," the old man would begin to cry like a baby. If the Wapaq should say, "Go to the afterworld," then the old man would die, according to the Koryaks' belief (*10*). Jochelsen, who traveled among the Koryaks in 1900–01, wrote (*11*): "Fly-agaric produces intoxication, hallucinations, and delirium. Light forms of intoxication are accompanied by a certain degree of animation and some spontaneity of movements.

Many shamans, previous to their seances, eat fly-agaric to get into ecstatic states. . . . Under strong intoxication the senses become deranged; surrounding objects appear either very large or very small, hallucinations set in, as do spontaneous movements and convulsions. So far as I could observe, attacks of great animation alternate with moments of deep depression. The person intoxicated by fly-agaric sits quietly rocking from side to side, even taking part in conversations with his family. Suddenly his eyes dilate, he begins to gesticulate convulsively, converses with persons whom he imagines he sees, sings, and dances. Then an interval of rest sets in again. However, to keep up the intoxication additional doses of fungi are necessary. . . . There is reason to think that the effect of fly-agaric would be stronger were not its alkaloid quickly taken out of the organism with the urine. The Koryak knows this by experience, and the urine of persons intoxicated by fly-agaric is not wasted. The drunkard himself drinks it to prolong his hallucinations, or he offers it to others as a treat."

The drinking of the Siberian mushroom eater's urine during these amanita debauches has been noted by many other travelers (*12*). An early satirical comment on this practice was made by Oliver Goldsmith in 1762 (*13*). It is reported that such urine can be drunk successively by as many as five people, passing in and out of one into the next, so that all of them can gain the hallucinogenic effect from one dose of mushrooms. It would be revealing to know the chemical composition of the hallucinogen which is passed around in the urine of these tribesmen, but this fact is not known. Studies looking toward the solution of this problem have been undertaken by Evan Horning and his associates at the National Institutes of Health. In 1953 Wieland and Motzel (*14*), employing paper chromatographic analysis, determined that this mushroom, *Amanita muscaria,* as well as *Amanita mappa,* and *Amanita pantherina,* all contained bufotenine, or *n-n*-dimethyl serotonin, an indole compound first isolated and defined chemically by Handovsky (*15*) in the skin of poisonous toads.

Arthur Drew has given an account of a modern version of *Amanita muscaria* poisoning (*16*). Drew reports, "the patient, a middle-aged tavern keeper, picked some wild mushrooms and ate them at 10:00 o'clock one night in October 1955. These mushrooms were later identified by the botany department as *Amanita muscaria.* Two hours after ingestion the patient had an explosive onset of diarrhea, profuse sweating, excessive salivation and vertigo. He fell asleep and wakened at 2:00 A.M. completely disoriented, irrational and violent. When he was admitted to University Hospital, Ann Arbor, Mich., his nail beds were dusky and he appeared cyanotic; blood pressure was 150/90, pulse 120, respiration 24 per minute, and his temperature 98.4°. He did not react to deep pain stimulation, but responded to pinprick. He was disoriented in all three spheres. Somnolence alternated with periods of excitement. He thought that he was in hell and identified the interne, nurses, and attending physicians as Christ, Satan, God, or angels. Nursing notes on admission indicate that he was threshing about in bed, talking constantly and irrationally.

"As the day wore on, the content of his hallucinatory and illusional output remained almost entirely religious. He constantly misidentified a tall resident physician as Christ. He kept referring to nurses and other attendants as God or angels. He felt that he was in the Garden of Eden, and then in hell. As evening came he cleared up mentally, lost his motor excitement, and felt relaxed. All laboratory tests were within normal limits. He appeared to be recovered on the following morning and was discharged."

Another mushroom-eating practice deserves mention. Ever since the time of the conquest of Mexico by the Spaniards in 1522 there have been references (*12, 17*) to a sacred fungus, *teonanacatl,* employed by the Aztecs and other Mexican Indians. Schultes (*18*) identified this as the mushroom *Panaeolus campanulatus* var. *sphinctrinus* in 1938. This "fungus of the devil," as the early Spanish priests called it, is now under study by R. Gordon Wasson (*19*) and his wife, Valentina P. Wasson. The Wassons have eaten the mushrooms and report visual hallucinations in brilliant colors, an ecstatic state of heightened perception, loss of time and space perception, and a serene feeling of inward peace while being drawn into an "otherworldly detachment" during dissociation periods of at least 6 hours' duration.

Wasson reports that there are many colloquial names for the mushrooms at the present time. He writes, "Every Indian language in Mexico has its own name for the divine mushrooms, and, as you would expect with sacred growths, every village is apt to use evasive or euphemistic names as well. In Nahuatl (the language of the Aztecs) the name was *teo-nanacatl,* 'God's flesh,' but we find in a village where classic Nahuatl is still used today that the word is *apipiltzin,* 'little children of the waters.'" Wasson has also noted the terms *nti-sitho, tu-m'uh, mbeydó,* and others used by other ethnic groups. He has identified species of four genera of Mexican mushrooms in use at this time for their hallucinatory properties, *Panaeolus, Stropharia, Conocybe,* and *Drosophila* (also called

Psathyrella). Species identification among these genera has not been completed. The chemistry of these mushrooms is not known. It would be interesting to determine whether or not they contain bufotenine. There is no report of urine-drinking among Mexican ritual mushroom eaters.

Other evidence suggests the use of bufotenine as a hallucinogenic substance. Fra Ramon Pane, who came to America with Columbus on his second voyage, described the ceremonial use of cohoba (*20*), a snuff derived from the seeds of the tree *Piptadenia peregrina,* as early as 1496, reporting that "it intoxicates them to such an extent that when they are under its influence they know not what they do." This inhalant was so potent in producing temporary states of dissociation that it became tribal custom for the women to tie up the Otomaco Indians when they used it. Stromberg determined that bufotenine was the active indolic principle of cohoba (*21*). Recently Horning *et al.* (*22*) were able to find a few milligrams of the snuff in the bottom of a Piaroan ceremonial snuff-box in the Smithsonian Institution. Paper chromatographic analysis showed that this snuff contained large quantities of bufotenine. Evarts (*23*) and Fabing (*24*) have also found that the effect of bufotenine in experimental animals is reminiscent of the effect of LSD-25. It would appear, then, that there is chemical, experimental, and anthropologic evidence that bufotenine is one of the hallucinogenic indoles, that it is distributed widely in nature, and that one of its chief sources of supply is the mushroom.

Berserksgang

A vivid description of the behavior of the Viking hoodlums is given by Schübeler, who relied on the renowned Norse historian, Munch, in his account (*25*): "In the old Norwegian historical writings it is mentioned, in many places, that in olden times there was a specific kind of giants who were called *Berserks,* that is, men who at certain times were seized by a wild fury, which, at the moment, doubled their strength and made them insensible to bodily pain, but which also deadened their humanity and reason, and made them like wild animals. This fury, which was called 'Berserksgang,' occurred not only in the heat of battle, but also during laborious work. Men who were thus seized performed things which otherwise seemed impossible for human power. This condition is said to have begun with shivering, chattering of the teeth, and chill in the body, and then the face swelled and changed its color. With this was connected a great hotheadedness, which at last went over into a great rage, under which they howled as wild animals, bit the edge of their shields, and cut down everything they met, without discriminating between friend or foe. When this condition ceased, a great dulling of the mind and feebleness followed, which could last for one or several days."

One of the curious aspects of *Berserksgang* is that it disappeared abruptly in the 12th century A.D., after plaguing Viking sociopolitical life for more than three centuries. In 1784, Samuel Lorenzo Ødman (*26*), a theologian at the University of Upsala, undertook to explain the phenomenon of *going berserk.* He reviewed the *Sagas* for descriptions of the state. He found King Halfden's Berserks depicted in *Rolf's Saga* in this manner: "On these giants fell sometimes such a fury that they could not control themselves, but killed men or cattle, whatever came in their way and did not take care of itself. While this fury lasted they were afraid of nothing, but when it left them they were so powerless that they did not have half of their strength, and were as feeble as if they had just come out of bed from a sickness. This fury lasted about one day."

Ødman also recounted a tale from the *Herverar Saga.* There were twelve brothers who lived on the island of Samsöe in Denmark. Orvar-Odd sailed to the island with his Viking ships, debarked and went inland to visit his cousin, Hjalmar. The twelve Danish brothers went beserk and killed his crews to a man. When he returned to the shore with his cousin, he encountered the Berserks, who were then in the enfeebled state after their fury. Hjalmar killed one, and Orvar-Odd killed the other eleven. Ødman saw in this fury followed by a state of exhaustion a paroxysm, and stated, "I am not of the opinion that these ecstasies can be explained as effects of a peculiar temperament or of autosuggestion because . . . they were not able to keep up their hated arrogance between paroxysms."

He argued further, "Since the vegetable kingdom gives us various means to bring our power of imagination into chaos and to induce the most ferocious excesses of courage, I am inclined to believe that the Berserks had knowledge about such an intoxicating means, and that they made use of it and kept it secret so that their prestige would not be reduced by the general populace's knowledge of the simplicity of the technique." He then reviewed the possible botanical products indigenous to Scandinavia which might have been used in this manner, and decided that *flugswamp,* the mushroom *Amanita muscaria,* was the one which solved the riddle of the Berserks.

He then compared the accounts of *Berserksgang* in the *Sagas* to the "amanita debauches" of the Koryaks and other far-eastern Siberians, and found them to be almost identical behavior patterns. In furtherance of his contention, he turned to theological history. He stated, "What in particular seems to me to argue for *flugswamp* is the fact that to partake of it is a custom from that part of Asia from which the pagan god Odin, with his pantheon, made their migration to our North. . . . Its [the mushroom's] use was spread by these hordes who used them and traveled northward. The history of the Berserks in our North begins with Odin's coming. Not only this, but it fits so well with the intentions of a conqueror who . . . could make himself feared and safe among foreign people."

More than a century later, in 1885, F. C. Schübeler, a physician and Norway's great botanist, arrived at the same conclusion. He wrote (*25*) "I still have a vivid remembrance that, on confronting all the symptoms that appeared under the so-called 'Berserksgang,' I came to the conviction that this paroxysm could hardly be anything but a kind of intoxication, the symptoms of which reminded me of the effects of taking *fluesop* [the Norwegian equivalent of Swedish *flugswamp*]. . . . Some time after I had come so far in this matter, I happened to find, while looking for something else, that the Swedish professor, Samuel Ødman had uttered the same opinion a hundred years ago."

Schübeler agreed with Ødman concerning the similarity between *Berserksgang* and the behavior of Siberian mushroom-eaters. He added that he could not agree with Munch that the condition was a "periodically returning insanity," because the symptoms were of a peculiar sort not ordinarily seen by physicians, and because they were the same each time a man went berserk. He argued that the effects could not be those of malted beverages because the latter produced quite different behavior patterns, and that distilled spirits were not known in Norway before A.D. 1531. In addition, opium and cannabis were unknown to the Nordics in saga times. He argued too, in favor of secrecy concerning mushroom-eating among the Berserks, and that for this reason no accounts of the practice were written down. He wrote, "The Berserks were feared by everyone, and they could, in a certain sense, enforce their pleasure. It is therefore in the nature of the case that they tried as best they could to keep this peculiar reputation in the eyes of the people. Hence, the knowledge of the intoxicant was probably transferred as a secret from individual to individual." It is worthy of note that the Wassons find a similar attitude of secrecy among the Mexican peons who use sacred mushrooms today.

Schübeler pointed out, too, that the more enlightened Viking leaders soon learned that the state was one which could be prevented, and therefore could be legislated against. He wrote: "Before Erik Jarl left Norway he called together (in 1015 A.D.) the feudatories and the mightiest peasants in order to deliberate with them about the lawgiving and the rule of the country. At this meeting campfighting (*holmgang*) was abolished, and Berserks and robbers were outlawed. In Thorlak's and Ketil's Icelandic Christian Law, which was adopted in 1123 A.D., there is the following decree: 'If someone goes berserk, he is punished with three years of banishment (*fjorbaugsgard*), and the men who are present are also banished if they do not bind him; but if they bind him, none are punished. If this is repeated, then the punishment occurs.'"

Schübeler regarded this as proof that the Vikings came to know that the paroxysm was temporary and preventable. *Berserksgang* ceased after this law was passed.

Fredrik Grön (*27*) reviewed the subject of the fury of the Berserks in 1929, and did not agree with the Ødman-Schübeler hypothesis. He pointed out that because of the general reliability of the historical Icelandic family sagas, none of the authors who have written about *Berserksgang* have raised any doubt about the reality of the phenomenon, but the explanations for it have varied over a wide range. Even in the more fantastic prehistoric *Sagas* there are enough common traits in the descriptions to establish a background of reality for the phenomenon. He feels, however, that the best explanation would be that of ecstatic fury psychogenically determined in a group of aggressive psychopathic personalities.

Bufotenine

Recently several of us have had the opportunity to study the effects of the intravenous injection of bufotenine in the human being (*28*) during the course of inquiries into possible chemical factors in the causation of schizophrenia (*24, 29, 30*). The subjects were healthy young long-term convicts at the Ohio State Penitentiary (*31*). All were well above the normal intelligence level, all had been college students, none were recidivist criminals, and all were considered to be relatively stable emotionally. Injection of 1 part of bufotenine base in 1.8 parts of creatinine sulfate were given steadily over a 3-minute period. A dose of 1.0 milligram of bufotenine produced only a sensation of tight-

ness in the chest and paresthesias of the face. Two milligrams produced a "tightness in the stomach" plus flushing and a purplish hue of the skin of the face. Four milligrams produced a sensation of tingling in the face and neck, a sense of chest oppression, a subjective report that "a load is pressing down from above and my body feels heavy," and a "very pleasant Martini feeling." This was followed by visual hallucinations of vivid red and black blocks moving before the visual field, inability to concentrate, and a feeling of great placidity and less anxiety than before the onset of the experiment. The face appeared lividly purple for 13 minutes.

Eight milligrams produced an immediate sensation of light-headedness, burning in the face, hyperpnea, deep purple facial color, and a sense of calm. At the end of the injection, the subject blurted, "I see white straight lines with a black background. I can't trace a pattern. Now there are red, green, and yellow dots, like they were made out of fluorescent cloth, moving like blood cells through capillaries." Six minutes later he reported that he felt relaxed and languid. In retrospect he said, "Even at the height of this, my mind felt better and more pleasant than usual."

Sixteen milligrams produced severe purpling of the face and facial sweating, tingling sensation throughout the body, a feeling that the chest was crushed, and the onset of hallucinations of purple spots on the floor, all in rapid succession before the injection was completed. Three minutes later the visual phenomena were gone, but space perception was impaired. The subject complained of difficulty in concentration, and he could not subtract serial 7's from 100, saying that he was "all loused up." During the next hour his face remained deeply purple, he was unable to express himself in words, stating that his mind felt crowded, and he showed motor restlessness, stating that he wanted to "walk it off" and that "my body feels nervous." Time and space perception were grossly impaired, and he expressed depersonalization feelings with such statements as "I am here and not here."

Nausea was an initial accompaniment of the syndrome as the injection began, and it proceeded to retching in the 16-milligram dose. Nystagmus and mydriasis occurred in all cases, and they increased in magnitude and duration as the dose increased. Pulse and blood pressure changes were minimal throughout. Another noteworthy finding was that of relaxed placidity and languor which all subjects reported for as much as 6 hours after injection. They lay contentedly in bed, feeling pleasantly relaxed, stating that they felt a lack of drive rather than a sense of fatigue (*32*). These observations were repeated on a later date, when six other convicts were used as subjects. The results were of similar type, except that lesser symptoms occurred if the injection was slowed to a 10-minute period rather than a 3-minute period.

It would appear, then, that intravenous bufotenine is hallucinogenic for man, that its action is rapid, and that the duration of effects is fleeting except in higher dosages. As the dose is increased, distortion of time and space perception occurs, as do depersonalization and bodily restlessness. Mydriasis and nystagmus make one thing that at least a portion of this drug's action is in the brainstem tegmentum. The picture that remains most vividly in the memory of the observers is the purple faces of these subjects. If the color of an eggplant were diluted, it would approximate the hue which their faces assumed. An artist could describe the color more accurately, but he would have to use the word "purple" in his description.

Students of model psychoses are confronted constantly with the general "schizophrenic" response of subjects despite wide individual variations in behavioral activity. Much of this case-to-case variation may be the result of personality differences, or it may be culturally determined. In many Orientals, for instance, the use of cannabis provokes erotic ideation and behavior for the most part, whereas in our culture it is used primarily by devotees of music who do not become sexually stimulated by the drug in most cases.

Within the dimensions of such variations, there seems to be much in common between *Amanita*-eating experiences and the response to intravenous bufotenine. When the purpling of the faces, as well as the hallucinations, the motor restlessness, the time and space distortion, the depersonalization, and the terminal languor of our experimental subjects are placed in juxtaposition with the accounts of the rage of the Berserks, the mushroom debauches of the Siberians, and Drew's recent case, the general similarity is striking.

It would appear, then, that recent observations on the human being tend to support the Ødman-Schübeler hypothesis that the Norse giants ate *Amanita muscaria* to produce the ecstatic reckless rage for which they are renowned, and which was a culturally accepted temporary psychotic aberration in their group. *Berserksgang* on a hill in Iceland in A.D. 955 might well have had the same neurochemical basis as an injection of bufotenine under experimental conditions in Columbus, Ohio, 1000 years later and 3000 miles away.

Summary

The ingestion of hallucinogenic mushrooms by Siberian tribes of the Kamchatka peninsula and by Indians of the Mexican highlands has been carried out in ritual and orgy for centuries. Ødman and Schübeler have advanced the hypothesis that the furious rage of the Berserks in the heyday of Viking culture a thousand years ago was brought about by the same agency, specifically, by the mushroom *Amanita muscaria.* A few years ago it was found that these fungi contain bufotenine, or *n-n*-dimethyl serotonin, a substance that is under scrutiny at this time for its possible neurochemical role in the causation of schizophrenia. Recent observations on the intravenous injection of bufotenine in man disclose that it is a hallucinogen and that its psychophysiological effects bear a resemblance to the *Berserksgang* of the Norsemen in the time of the *Sagas.* These observations appear to offer support to the Ødman-Schübeler contention that the famed fury of the Berserks was what we would call a model psychosis today.

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32. E. L. Kropa and R. D. Morin of the Battelle Memorial Institute kindly assisted in making these observations.

Path of Atoms through Generations

GEORGE HEVESY

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THE number of atoms inherited from the matter which is passed on to the next generation depends on three factors: (i) the fraction of the total number of atoms of the mother which were passed on to the newly born; (ii) the number of inherited maternal atoms that are replaced before birth of the grandchild by atoms from nutrients; and (iii) the number of maternal atoms still present at pregnancy which can be used for development of the embryo of the next generation.

The quantity mentioned first depends essentially on the weight ratio between the mother and the newly born. This quantity does not vary much from element to element. However, sodium, chlorine, and sulfur are preferred by the body of the newly born, whereas potassium, calcium, magnesium, and phosphorous are preferred by the body of the mother. The greatest discrepancy from an equilibrium distribution is seen in calcium. The concentration of calcium is about 3 times larger in the body of the mother than in the body of the newly born. The reason for this is the calcium deficiency of the developing skeleton of the newly born.

The loss of inherited atoms before reproduction of the animal and the usability of the still-present, inherited atoms for the development of the embryo of the next generation vary decidedly from element to element.

It has long been recognized that food supplied to the body is not only used to supply energy but is also of great importance in the replacement of used parts of the body. However, only in the last decade has interest begun to develop in the quantitative side of the second function of the nutrients and in determining the lifetime of molecules and atoms in the bodies of animals and plants.

Replacement of Sodium Atoms of the Body

As the first example for the replacement of atoms present in the body by atoms absorbed from food, we shall consider the fate of the sodium atoms in the organism. If radioactively labeled sodium—for example, in sodium chloride—is supplied to the body, the supplied sodium ions mix rapidly with the sodium ions circulating in the body fluid. Therefore, the percentage of elimination of radioactive sodium is equal to the percentage of elimination of the total amount of circulating and easily exchangeable bound sodium in the body.

Each day about 4 percent of the radioactive sodium present in the human body is eliminated (*1–3*). Therefore, the half-life of the sodium atoms circulating in the body is about 2 weeks. About 54 grams of sodium are present in the extracellular fluid of an 80-kilogram person. To this must be added an intracellular amount of about 33 grams. Of the latter, about four-fifths is contained in the mineral constituents of the skeleton (*4*). The intracellular sodium and part of the mineral skeleton sodium enters comparatively fast into exchange with the circulating extracellular sodium. Two-thirds of the mineral skeleton sodium, about 18 grams, is anchored so strongly that it is retained to a large extent throughout life (*4–7*). Of the sodium that is not strongly anchored—a total of 70 grams (2×10^{24} sodium atoms)—not a single atom is present in the body after 162 weeks. These atoms are all replaced by sodium atoms from the food.

All the chief ingredients of the body, with the exception of hydrogen, nitrogen, and sulfur, take part in the build-up of the apatite in the bone. The amount of conservation of a part of the individual atoms of an element in the body for a long or very long time depends foremost on the factor of how much of this element enters into the bone apatite and is retained there temporarily.

The evaluation of the degree and the speed with which atoms of the mineral bone skeleton are replaced by atoms of the blood fluid or the lymph is therefore of the greatest importance for our problem.

Exchange of Phosphorus Atoms of the Skeleton Structure

The question of whether and to what degree the atoms of the skeleton structure are exchanged with those of the blood and the lymph was raised only after radioactive phosphorus became available as an indicator for phosphorus atoms. Immediately after the discovery of artificial radioactivity by Frederic and Irene Joliot-Curie, radioactive phosphate was produced. This was first used to answer the question of whether an exchange takes place between the phosphate ions of the bone and those of the blood (*8*). A few minutes after radioactive phosphate had been given to an adult rat it could be traced in the bone structure. The content of phosphorus-32 in the bone skeleton increased very rapidly at first; after 1 hour, however, the increase was much slower.

The obvious interpretation of these observations was that a rapid exchange takes place between the marked phosphate ions of the fluid blood and the phosphate ions lying on the surface of the apatite crystals of which the bone structure is built. Hand in hand with this exchange goes a biological recrystallization of the skeleton. Crystals of the bone structure go into solution, and the new crystals, which have been formed from the labeled fluid blood, have to be radioactive. The biological recrystallization—that is, the renewal of the bone skeleton—governs this exchange process nearly completely after a short time. Autoradiographs taken by LeBlond and coworkers (*9*) illustrate clearly that radioactive phosphate is absorbed by the epiphysial plate of the adult rat 5 minutes after injection (compare Fig. 1). After 2 hours, the absorption is very distinct.

It follows from the classical investigations of Paneth (*10*) that the ions in the topmost molecular layer of a crystal powder enter into an exchange equilibrium with the ions of a surrounding solution. This statement holds only for a part of the ions which are located in the topmost molecular layer of a well-developed crystal surface—of a mineral, for example. Even if only a small fraction of the topmost molecular layer of the bone apatite took part in the exchange proceedings, it would be sufficient for the removal of an important part of the phosphorus-32 from the plasma which was added to the blood fluid. Three percent of the bone phosphate, or maybe even more, settles in the topmost molecular layer of the bone apatite, and the phosphorus content of the latter is about 700 times greater than that of the blood plasma. If after a while 1 milligram of the phosphate of the bone skeleton shows the same radioactivity as 1 milligram of phosphate of the blood fluid, it could be concluded that the total phosphate content of the bone skeleton was renewed during the experiment. This, however, is not at all the case. The experimental conditions for determining the part of the bone skeleton which is renewed are very unfavorable. The specific activity of the plasma phosphate falls at first very rapidly, later on very slowly, and shows fluctuations during the necessarily long duration of the experiment. In order to simplify the conditions for the experiment, the specific activity (activity per milligram) of the bound phosphate of a rabbit was held constant for 50 days by repeated daily injections.

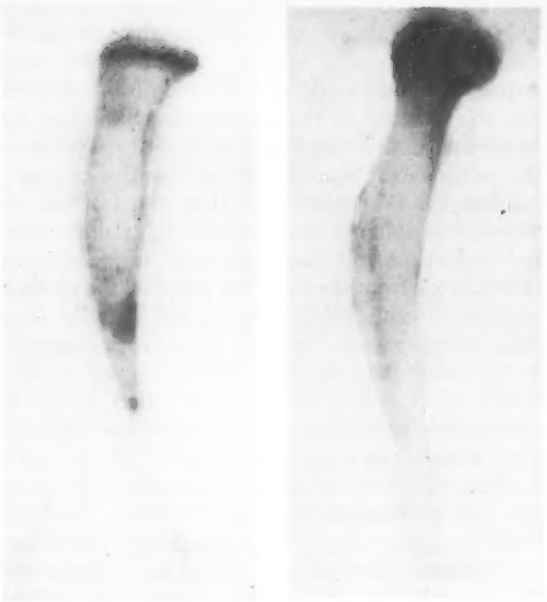

Fig. 1. Phosphorus-32 absorption by the tibia of an adult rat 5 minutes after intravenous injection (left) and 120 minutes after intravenous injection (right). (×3) [Photos courtesy of C. P. LeBlond]

It followed that about one-third of the soft epiphysial bone skeleton was renewed during the duration of the experiment (*11*). From the hard diaphysial bone structure, a considerably smaller fraction is renewed. The exchangeable part of the bone structure of the rabbit has therefore to be limited to about one-third.

Fate of Calcium Atoms

In order to be able to pursue the fate of calcium through several generations of mice, we had to know what fraction of the calcium ions in the bone skeleton of mice is renewed during a lifetime. Numerous experiments concerning the calcium metabolism of the skeleton have been described (*12–16*). In determining the fraction of the exchange-

able skeleton calcium, we continued the afore-mentioned experiments, and we replaced the very tedious method by another. We did not investigate the replacement of the inactive bone calcium by labeled calcium in the fluid blood. We bred animals that were evenly marked with radioactive calcium, calcium-45. We determined then the fraction of radioactive calcium ions that left the animal during its lifetime and that were replaced by inactive calcium ions from the food. We supplied the mother with radioactive calcium of limited activity (less than 0.5 microcurie) so that no radiation damage to the animal had to be feared. In this way we obtained an evenly activated generation of mice, which cannot be obtained by any other method. Each member of a single generation had the same calcium-45 content within a few percent. The mice received radioactive calcium with their food till they were grown up. One of the siblings was killed at birth, and the radioactivity of its skeleton was determined. The remaining animals were killed at other times and examined. It became evident that after more than 1 year, which represents a considerable part of the life span of a mouse, 67 ± 7.9 percent of the original calcium atoms of the skeleton could still be found. Therefore only one-third of the bone skeleton is renewed.

In another series of experiments we examined newly born mice right after birth. The other mice were transferred to an inactive foster mother and analyzed at different times in the following 1.5 years. Figure 2 shows the results of some of these experiments. One should expect that during the intense growth of the first week of life a large part of the atoms taken over from the mother are disposed of and replaced by those from food. In the first 50 days, the loss of atoms from the mother is considerable. However, in the whole life of a mouse it does not amount to more than 50 percent.

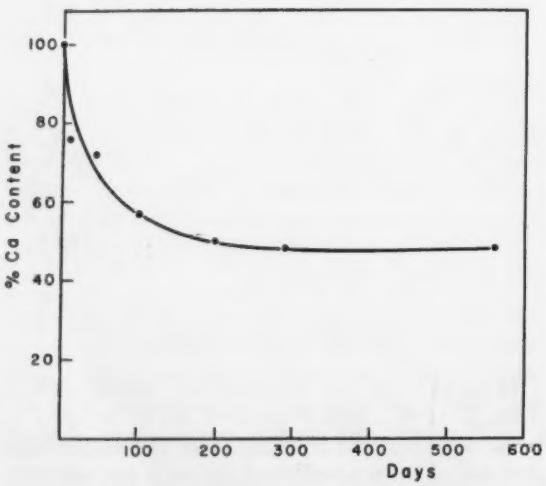

Fig. 2. Loss of inherited calcium atoms during the life of a mouse. We determined the total activity of siblings whose mother was fed calcium-45. The offspring were killed at different times.

We found about 1/300 of the labeled calcium atoms that the mother of the second generation received at its own birth in the newly born of the third generation. The loss in calcium atoms of the ancestors before propagation and through limited transmission to the offspring is repeated from generation to generation. It can therefore be found by extrapolation that, of the 6×10^{21} calcium atoms to be found in a mouse weighing 30 grams, not one is present in the 11th generation of its descendants. The loss of labeled calcium atoms in the transition from the second to the third generation of one strain of mice amounted to 1/200 only. Calcium atoms from the mother should no longer be traceable in the 12th generation of these animals.

That the calcium atoms of the ancestors can be traced in such a long series of descendants can be ascribed to the fact that about 99 percent of the body calcium is located in the skeleton. The skeleton is therefore able to preserve an important part of its building materials. However, only a fraction of this calcium is available for the structure of the body of the descendants.

Fate of Water Molecules

The calcium and phosphorus atoms of the ancestors of the mouse (very similar conditions should be valid for human beings) are traceable in a long series of generations in the descendants. However, the water molecules that the mother transmits to the descendants disappear during the life of the first generation.

Shortly after the discovery of heavy water, we were able to determine, thanks to the support of H. C. Urey, who discovered this isotope, the half-life of water molecules in the human body. We found that this amounts to about 10 days in the body (*17*) for normal water intake. The half-life depends on the amount of water consumed. Schoerb and his coworkers (*18*) also found recently a half-life of 10 days with a normal daily intake of 2.7 liters. In the case of a rather large daily water intake of 12.8 liters, the lifetime fell, however, to 2.5 days. In the case of a normal water intake, after 810 days not a single molecule of the 2×10^{27} water molecules originally present remains in the human body.

The half-life of water molecules in rats was determined to be 2.5 to 3.5 days. In the mouse it

should amount to about 2.5 days. After 340 days, therefore, not a single maternal water molecule is present in the mouse.

Owing to the large part that the element calcium plays in the development of the skeleton, it is preserved best in the descendants. However, even of this element, not a single atom of the ancestors is present in the 11th and 12th generations. This evidence illustrates the independence of the hereditary pattern from an atomic share of the forefathers. It is well known that the hereditary pattern depends on the ability of the organism to group in atoms, molecules, and higher cellular units in a certain manner. A protein composed of 20 different amino acids and having a molecular weight of 100,000 is able to appear in more than 10^{1270} isomers, as calculated by Staudinger (*19*). Therefore, incomparably more types of proteins can exist than the number of water molecules (10^{46}) which are present in the oceans of the world. Since hereditary patterns are tied to the reproducibility of individual proteins or nucleoproteins, there is room for new individual hereditary patterns as long as the number of human beings has not reached 10^{1270} or even a larger figure.

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World Time Clock

Located at the entrance to Tomorrowland, Disneyland, in Anaheim, California, the huge world time clock shown on this month's cover gives the hour and minutes in every part of the world. The clock was designed by William Tuntke of Disney Studios and was built by U.S. Time Corporation. The flags in the background represent the nations of the world. Our photograph was made by Robert W. Young of Huntington Park, California.

Social Science Techniques: a Problem of Power and Responsibility

EDWARD GROSS

Dr. Gross is associate professor of sociology at the State College of Washington, Pullman. He received his training at the University of Toronto and the University of Chicago, and from 1951 to 1953 he conducted intensive field research on the morale of servicemen for the U.S. Air Force. His research has been concentrated in the specialties of industrial sociology and small group dynamics.

THE right of the scientist to inquire freely into the secrets of nature has been fought over for centuries. With the coming of modern social science, human society became part of the order of nature, and man, the great observer, became the observed. But, in fighting for the right to inquire, the social scientist early found that he had two antagonists. There were those who denied that human beings could be studied scientifically (and they included, strangely, many physical scientists), and there were those who declared that, whether human beings could be studied or not, they *should* not be studied, for to do so represented an impious invasion of privacy. The first antagonist was vulnerable, for the social scientist could, and did, prove him wrong by developing techniques for penetrating deep into personality and social and political life. But the second antagonist was armorproof against all scientific attacks, for there was, and is, no way to prove him wrong. He was like a property owner who had erected a "No Trespassing" sign on his own property in accord with his legal rights. One could try to convince him, one might point out that others had taken down their signs, but one could not prove that *he* should do so too. The social scientist found then that there was only one thing left for him to do—develop new weapons, secret weapons.

It was one of these weapons—a hidden tape recorder—that was used in the jury room of the court of Judge Delmas Hill of Wichita, Kansas, in May 1954. Its detection and the subsequent public investigation, in October 1955, of those responsible for the "bugging" of the jury have raised important legal and political questions. But the case also raises a scientific question, for it introduces a wholly new dimension to the old question of the scientist's right of inquiry: What are the rights of subjects to be free from scientific inquiry?

At first glance there seems to be no problem at all: all a prospective subject has to say is *No*, and that ends the matter. What is unique about the jury case, one may insist, is that the jurors were not aware that they were being studied, and therefore, had no chance to say *No* to the investigators. But if we look closely at investigative techniques that are the stock-in-trade of social scientists, we discover that many of them are designed to get information from the subject without his being aware of what he is revealing or that he is even being studied at all. The social scientist has built a great arsenal of secret weapons (the tape recorder being a lesser and rather poor one), and it is to these weapons that we owe a great deal of our knowledge of human behavior, especially about personal or touchy matters.

Such secret techniques represent a clear gain for the social scientist. They provide him with an immensely penetrating optic for observing man, and, because of the power of the techniques in breaking through the natural reserve and suspiciousness of human subjects, they place the social scientist on a footing roughly equal with that of the physical or biological scientist. But the very power of these techniques makes it necessary for controls to be provided on their users. The social scientist can never ignore the fact that, since his subjects are not bugs or trees or guinea pigs, but human beings, their rights cannot be summarily ignored. The controls on the scientific behavior of social scientists must, therefore, rest ultimately on moral considerations.

Let us look, first, at some of these secret techniques and the vast power they give to the social scientist. Then we will be in a position to consider the types of controls they require. It should be emphasized that these techniques are secret only in the sense that the subject himself is not aware of what he is revealing. They may be found described in research books in any large library. Perhaps a better word for them is *indirect,* rather than secret.

Power of Indirect Techniques

One of the most potent techniques was not actually invented by the social scientists but was borrowed from the psychotherapists. They had long faced the problem of the recalcitrant or sullen patient and had been forced to work out ways of dealing with him. One of these ways was a special interview called nondirective.

Most interviews are highly directive—the interviewer asks questions and the subject answers: How old are you? When did you first notice this problem? Whom do you suspect? What did you do next? What did she do then? Why? It had been discovered that questions like these have a way of arresting the free flow of material, for each makes the patient stop to consider the question instead of going ahead with what he was going to say. He further is made aware of the fact that he is answering a question, and he tries to give the best (that is, the most acceptable) answer that he can, and it is usually as intellectual as he can make it.

By contrast, the function of the nondirective interview is to keep the patient going to deeper and deeper levels of personality, and the interviewer does this mainly by reflecting the feelings already expressed by the patient. The statements (or questions, if they may be called such) will be: You say you like your work but there's not enough money in it? So you feel your sister has always tried to get the better of you? You love your little boy but at times get so mad at him you feel like killing him? Now, in the therapeutic situation, the end-result is to get the patient to develop insight into himself. But the social scientist quickly recognized that he could use the same procedure to give *him* insight into some aspect of his subject's life that the latter did not discuss, for the nondirective interview has the mysterious effect that, as the person talks freely (the interviewer never judges or expresses attitudes), he reveals not only material he did not want to talk about but material he *could* not talk about, since he was not even aware of it himself. The reasons for this result are not very clear, but the catharsis the subject enjoys seems to be partly responsible. The subject secures a release of deep feelings and, once the release begins, the feelings seem to come tumbling out in great profusion, a phenomenon akin to the releases experienced in many violent games, artistic expressions, religious revivals, mob behavior, and sexual orgasms.

Nondirective interviewing is tricky and requires extensive training. If skilled persons are not available and time is short, the social scientist sometimes shows no mercy—he is not above outright fraud or lying. Questionnaires dealing with all manner of problems have been given out, and the subjects have been told that they were "intelligence" tests or "information inventories." This practice is designed to increase motivation. Most subjects, when told their intelligence or knowledge is being tested, will try very hard to do well, in part to impress the examiner and in part to reassure themselves. A related procedure is the use of planted questions—significant questions about touchy matters strategically placed in an array of innocuous questions. These methods are risky and work best when subjects are not very well informed or "test wise," and when the examiner will probably not see them again. They may be used in army induction or screening tests or with beginning students. Here the only danger at the time rests with the subject who flunks and has to take the test again. He had to be fairly stupid but not extremely stupid. Even then, a way out is to prepare alternate forms of the same test.

Perhaps the most ingenious approach—one that seems to be proof against even the most intelligent, sophisticated, and test-wise subject—is the use of projective techniques. The subject is given a vague or unstructured medium, usually a picture or a painting, such as ink blots (the Rorschach), shadowy photographs (the thematic apperception test), cloud pictures, and the like. He is then asked what the picture looks like, or to tell a story about it. In so doing, he does not realize it, but he reads himself into every picture. Then, through elaborate analytic procedures, literally every word is held against him—actually, this is not an adequate descriptive metaphor, since it is the form more than the content of his remarks that is significant. It has been found that it is practically impossible to malinger on these tests, although one can give evasive responses such as "that's a nice picture" or "looks like waves on the shore" (many of the Rorschach pictures may be so interpreted). But even these responses are meaningful, for they raise the question of why the subject is evading, particularly if he evades only certain pictures. I have some knowledge of the Rorschach test and, on occasion, have tried deliberately to fabricate a story. But I have found, to my chagrin, that even though I was aware of the interpretation to be made of my responses, my stories or descriptions always came out the same (in form). After all, it was I who was making up the description and there could be nothing else but me in it, or rather, my interpretation, my way of looking at the world —in a word, my personality. It is possible that extremely imaginatively gifted persons, such as poets and writers, might be able to fabricate a story

which in no way reflected their own personalities. This is doubtful, but such people are happily (for the social scientist) very few, and most of them would, in any case, refuse absolutely to take any test. The only thing left for the social scientist is to study their poems or stories, which are regarded by some analysts as elaborate personality projections (for example, Freud's comments on Dostoevsky's handling of love).

Engineering Cooperation

For their success, the techniques so far described all require at least a minimum of cooperation from the subject. He might not know what he is revealing, but he has to agree to take the test. What is to be done in the case of absolute refusal? The most obvious action is simply to ask the subject why he refuses, and this is often highly revealing. In a study of the attitudes of servicemen, one of my questionnaires was returned with none of the attitude questions answered. I immediately sought out the man—he was an experienced sergeant who feared no researcher—and he said this, in part:

"I've seen you boys come and go for years. I've filled out so many questionnaires asking me for my gripes and opinions that I'm bored with them, and I've never seen 10 cents' worth of good come out of any of them. What are they sending you guys around for anyhow? They know what we need out here. Maybe they don't know everything, but they know the main things. And don't tell me they haven't got the money. They're paying *you,* aren't they? I'll give you a statement for your book, and maybe you won't like it. They ought to take the money they pay you and use it to put in a decent pool table in the day room. You can quote me on that."

I was delighted to get such a frank expression of attitudes. Not only had his remarks revealed his answers to some of the attitude questions on the questionnaire that he had refused to fill out, but his outburst broke down the reserve between us, and he later became one of my friends and a good subject as well. Nor was I offended at his personal reference. If a person is hurt easily, he had better not enter social science. One must see the door that is slammed shut in one's face not as a rebuff but as a challenge.

More revealing is an approach that may not involve any formal interviewing at all—observation. This the historian has always used, the economist leans heavily on it, the archeologist has no other method. It is the method that Sherlock Holmes was always calling (incorrectly) deduction, and it has reached its most elaborate development in the work of the social (or functional) anthropologist. The social anthropologist, particularly the breed spawned by Malinowski and Radcliffe-Brown, is, in a sense, the greediest of all social scientists. He has little interest in individuals as such; he regards the sociologist's emphasis on groups as little more than trivial; and he passes impatiently over isolated analyses of economics and political life—he demands, and is satisfied with, nothing less than the entire culture of a people. And he treats an entire culture or society as one case or illustration. In order to satisfy the scientific requirement of many cases, he has entered one culture after another, many of them exotic and highly different from his own, and many with people in them who were highly suspicious of, or hostile toward, outsiders. He had to learn ways of gaining acceptance and confidence—in some cases, his very life depended on his success.

He learned the significance of role structuring: What should he be—objective researcher? itinerant trader? government agent? From his graduate training, he knew a good deal about culture in general or the cultures of peoples related to the one he was going into. So he could ask himself: What can I observe first without arousing opposition? It might be their work—canoe-building—but not their family life or religion. But while out on a sea expedition the canoe might start to ship water, and the builder might then say: "I must return home immediately, for this is a sign from the gods that my wife is unfaithful to me. The wanton! I shall demand the return of the bride-price from her people!" The anthropologist learned the value of his continuing presence in building rapport. A verbal assurance of confidence rarely convinces anybody. Nor is it better to repeat or elaborate such assurances—this may worry the subject. Confidence, instead, may come simply to be taken for granted after the people know the researcher well enough to have decided that he is a "good egg" and can be trusted. And this takes time. Malinowski describes his own experience among the Trobriand Islanders as follows.

"These [the proper conditions for ethnographic work] . . . consist mainly in cutting oneself off from the company of other white men, and remaining in as close contact with the natives as possible, which really can only be achieved by camping right in their villages . . . if you are alone in a village beyond reach of this [white contact], you go for a solitary walk for an hour or so, return again and then quite naturally seek out the native's society, this time as a relief from loneliness, just as you would any other companionship. And by means of this natural intercourse, you learn

to know him, and you become familiar with his customs and beliefs far better than when he is a paid, and often bored, informant."

Malinowski then tells us that this approach had a remarkable result. "It must be remembered that as the natives saw me constantly every day, they ceased to be interested or alarmed, or made self-conscious by my presence, and I ceased to be a disturbing element in the tribal life which I was to study, altering it by my very approach, as always happens with a newcomer to every savage community. In fact, as they knew that I would thrust my nose into everything, even where a well-mannered native would not dream of intruding, they finished by regarding me as part and parcel of their life, a necessary evil or nuisance, mitigated by donations of tobacco."

When studying our own culture, if he is denied access to any organization—factory, club, religious society—the researcher might take his cue from the anthropologist and camp right in it by joining the organization, a device made respectable by calling it participant observation. A famed sociologist once said to a graduate seminar: "One of the great problems in field work is getting into the woman's world—the world of meal-preparation, courtship, and babies. To solve this problem, gentlemen, the best piece of research equipment I know is a trained wife. If any of you are not yet married, and you are planning a life in social research, select your wife with great care."

The late Justice Brandeis certainly had some presentiment of techniques such as these when, in his vigorous dissent to the majority decision in the Olmstead wire-tapping case (1928), he wrote: "Ways may some day be developed by which the Government, without removing papers from secret drawers, can reproduce them in court, and by which it will be enabled to expose to a jury the most intimate occurrences of the home. Advances in the psychic and related sciences may bring means of exploring unexpressed beliefs, thoughts and emotions. 'That places the liberty of every man in the hands of every petty officer' was said by James Otis of much lesser intrusions than these." And to the extent that organizations, including the government, hire social scientists, to that extent their techniques are at the disposal of those organizations.

Danger of Indirect Techniques

The social scientist—there he stands. Physically he is often a little man, slightly bald; he may stutter a bit when he speaks; he has a wife and children and goes with them to church on Sunday. He may not be imaginative or clever, but he has listened to what imaginative and clever men have taught; he may not be courageous, but he has learned the techniques that courageous men discovered; he may even be afraid of people, but he knows how to manipulate subjects. There he stands —a resolute man, a pillar of might, a dangerous man.

Now the reason that the social scientist makes use of indirect techniques is clear. He wishes to get data in the natural setting where the data actually occur (*in* the jury room), and if the subject were aware, he would color his responses or not respond at all. This problem is unique to social science, for one can rarely duplicate actual human conditions in the laboratory. The biologist does not have to be concerned that the microbe will behave any differently in the laboratory from the way it behaves in its natural habitat. The stars go on their way whether astronomers look at them or not.

The social scientist has therefore, little choice. Either he will use indirect methods or he will not get his data at all—at least a large part of the data that interests him. Assuming then that the right of the scientist to collect such data continues to be granted, he will continue to use his methods. Planting secret microphones is one of those methods and, if it is not forbidden by law, will probably remain. I imagine that the experience in the jury "bugging" case will be cited in many graduate schools of social research as an example of what may happen when research is sloppy. The researchers in the case will be castigated, not only for violating the law (if they did so), but also for amateurish bungling. The result may be a search for more ingenious devices and a stricter training of researchers.

But such a course of action (assuming it were pursued) does not successfully resolve the matter, for it fails to touch at all the central issue: Do subjects have any rights to be free from scientific inquiry? On second thought, this course of action does provide one answer, if only tacitly. The answer is *No,* no rights whatever (except in the few cases where the law provides protections). If this is the answer, then the social scientist is, indeed, a dangerous man. But I do not consider the answer, in itself, acceptable or defensible.

A Model—the Physician-Patient Relationship

The social scientist is potentially dangerous in the sense that anyone who has access to secret material is. But the question is not whether to permit appropriate persons to have access to secret

material. Someone must, or the material is useless. The person who has access to secret material is dangerous only if his use of that material is uncontrolled. Everyone has had at least one experience in which he reveals secret material about himself and does so willingly, even eagerly—an interview with his physician, and it is a case in point. We are willing to reveal our innermost secrets to him for two reasons: (i) we are in accord with the purpose for which the information is being revealed (health improvement) and (ii) we have confidence that the physician will not abuse the information. Our confidence, in turn, rests on the physician's position of prestige in society and our belief that he has been adequately trained in the ethics of the doctor-patient relationship. And therein, it seems to me, lies the proper course of action.

Clarification of Purpose

The social scientist will have to make clear, in a given case, what *his* purpose is. In the jury case, the purpose was stated to be "improvement of the jury system," which is certainly vague and must be spelled out much more clearly. It must be clear also that the information cannot be secured in any other way except through an indirect technique. Social scientists are as lazy as most people and not infrequently use a particular technique because they are accustomed to it or because they have not given much thought to alternatives. The social scientist has no more right to use a particular technique if it is not necessary than a doctor has to ask a patient to undress if that is not necessary.

But to say that the social scientist must clarify his purpose raises the further question: Clarify to whom? The success of indirect techniques requires that the subject be *not* aware of the inquiry. The major effort toward clarification must be addressed to society at large. And I think that the most effective way to do it is by continually communicating findings of current research in understandable language to the public audience.

The social scientist cannot consider his job finished when he has published in his own professional journals. Many social scientists consider any other practice beneath their dignity—"mere pamphleteering"—a good way to insult a social scientist is to call him a "popularizer." The only audience such scientists feel it fit to communicate with is their own group of colleagues. But the group cannot afford to indulge for long in the luxury of cliquishness. In any case, the superior attitude is often one of sour grapes—I would guess that the files of quite a few would reveal a large number of rejection slips from major magazines (which, unlike the professional journals, actually pay money for articles). I know that part of the bias against popularizing stems from the fact that it is often inaccurately done. But this is usually because it is left to the outsider or amateur to do it. Pamphleteering—I should prefer to call it communicating—is part of the scientist's job. And for the social scientist, his ability to secure cooperative subjects—his very data—depends on an effective communicating job. The social scientist who leaves this task to the "mere pamphleteers" is a free-loader, living off the margin of good will that the pamphleteers have created.

But what of the subject himself? If he may not be informed of the purpose of the study, what may he be told? What has he a right to expect? One thing at least—no lies. This is not only bad morally; it is also bad research. The social scientist who says, "What difference does it make? They'll never see me again" is not only a fool; he is a threat to the survival of social science. The subjects may not see him, but they will see others like him, and, in any case, such a practice cannot long be kept a secret. Sooner or later, especially as research goes on with more and more subjects, there will come some in the scientist's test group who will say: "He says it is a test of intelligence but he may be lying." When this happens, research is dead. If the general public ever developed such an attitude toward, say, physicians—that is, if it ever reached the point where it regarded every physician as a possible liar and one who, therefore, could not be trusted—the medical profession would not last an hour. And neither would social science research.

Positively, the subject has a right to be told in a general way of the purpose of the study. It is not necessary, or even desirable, to tell all. All professionals are faced with the problem of how much to tell the patient or client. And they learn, as Everett C. Hughes put it, to double-talk—that is, to talk in one frame of reference to their colleagues and in a different frame of reference to their patients or clients. If the professional were to tell the patient or client everything in technical language, he would only alarm him and not tell him much. So he tells him *enough*—all he needs to know to be motivated to cooperate. There is a great difference between the physician's thinking to himself: "That cough is probably unimportant, but he might have TB," and the patient's thinking: "*I* might have TB!" It would probably be wise not to raise the subject until some more crucial diagnostic tests have been made, and this means that the patient must not know, for the moment, that he is being tested for TB. The social scientist

can do the same. He can tell the subject enough—although what he says must be true—but only enough to secure cooperation.

Building Confidence

But no amount of clarification of purpose will be effective if there is no confidence that the social scientist will not abuse the information revealed to him. Means must be provided for giving assurance that gathered data will not be used to provide material for an exposé. The physician's obligation of silence about the secret life of his patients applies equally to the social scientist and his subjects. Such confidence is not easy to build—it is certainly not created by verbal promises. The promise must be kept and kept indefinitely. Nor can one weasel out of it by securing the subject's permission. I am always disturbed when I read that a group of social scientists who have studied some private organization, such as an industry, ask the owners for a release from their agreed-upon understanding not to reveal sources. The industry may agree, but reluctantly, for to refuse may be felt to be bad for public relations, an admission that the industry has something to hide. Even where there is enthusiastic agreement, I think public confidence is shaken, for the owners of other industries are likely to feel uneasy and think: "These fellows assure you they won't violate confidence, but you never know when they will ask you to release them. The safest thing is not to let them in at all." Sometimes enthusiastic agreement is shown only because the owners feel that the company will be shown in a good light. In this case, the social scientist is being used as a publicity agent.

Moral Obligations

But above all the social scientist must be continually conscious of the fact that he is himself a member of our society. This means that he may not, any more than anyone else, violate the law or general moral understandings. It is no defense to say that he has techniques that enable him to do so—so does the gangster. Nor may the social scientist feel any special pride in the fact that the indirect nature of his techniques makes detection unlikely. He cannot conceive of himself as an observer only, as one who stands off and surveys the world as a kind of curious drama. If it is a drama, then he is on-stage himself. The social scientist tries to keep values out of his research; they are felt to interfere with objectivity. A favorite way of putting the matter is this: "We all have many roles. I have a role as a citizen and with it go certain faiths and beliefs. But when I enter my laboratory, I am a scientist, and I leave my values at the door, along with my galoshes." This sort of schizophrenia may be possible for the physicist, but it is not for the social scientist. For it is *as a social scientist* that he is a citizen. This is his position in society, just as others are blacksmiths, physicians, or newsdealers, and society pays him for it because he makes a contribution it values. But society will not long pay a man who violates its laws, its mores, or its tacit understandings. And if the man claims that his work demands it, society is likely to put an end to his work. Nor is the social scientist abroad immune from the controls of our society. He is still a member of our society, nay more, a representative of our society, and he has the same obligations that we enjoin on any visitor to a foreign land.

The question remains of how these controls are to be enforced. I doubt that legal protections alone would be sufficient. Even in the case where a subject's legal rights may have been violated, he may not, in practice, be able to protect himself. He may not have the money to fight a difficult case through court, and even if he has, a court case is likely to force him to reveal, for all the world to hear, the very secret things he did not want even the social scientist to know. He may prefer to salvage some solace from the fact that few people read professional social science journals.

In order to have controls that work, they must come from within the profession itself, just as the strongest controls on any professional come from his own colleagues. Now I am well aware of the fact that many, perhaps most, social scientists feel no need for controls. In practice, although they might do so, they do *not* lie to their subjects or ever violate a confidence. They are extremely careful of a subject's personal or private life and accord him complete respect for any rights that he claims. But they do so not because they have been formally trained to do so as researchers, but because of their own upbringing as individuals. From this point of view, the social scientist learned more at his mother's breast than he did at his professor's feet. It is no contradiction to point out that in research courses the student is told that he should not violate confidences and should respect a subject's rights. These suggestions are justified, not in moral terms, not in terms of the understandings that a member of our society should respect, but as being, simply, good for research. It seems to me that the responsibility of graduate schools of social research extends further than this, for the university, the social scientist it produces, and the subjects he studies are united as members of the same moral community.

Chemical Research and Education in Japan

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THE status of research in the field of chemistry in Japan may be most appropriately reviewed by looking at the present activity of the Chemical Society of Japan. The Chemical Society of Japan, which has 17,000 members at present, is the largest society in Japan in the field of natural sciences. The society acquired its present form in 1948, when its forerunner was amalgamated with the Society of Industrial Chemistry. The history of the Chemical Society represents the history of both pure and applied chemistry in Japan, while its recent activity reflects the status of chemical research in Japan today.

The society celebrated its 75th anniversary in 1953, and issue No. 10 of volume 6 of its bulletin, *Kagaku to Kogyo* (*Chemistry and Industry*) was published as the memorial issue. This issue contained not only reviews of research in various fields of pure and applied chemistry written by research scholars who are leaders in their respective fields, but also a table of the main historical events in chemical research, education, and industry inside and outside Japan since the establishment of the society. The contents of these reviews will be of interest to anyone who wants a survey of chemical research in Japan.

In addition to *Chemistry and Industry,* the society publishes three technical journals, two in Japanese and one in foreign languages. One of the two journals written in Japanese, *Nippon Kagaku Zasshi,* covers the field of pure chemistry, and the other, *Kogyo Kagaku Zasshi,* covers industrial chemistry. The journal written in foreign languages, the *Bulletin of the Chemical Society of Japan,* includes papers from the sections of both pure and applied chemistry.

Trend of Chemical Research

The trend of chemical research in Japan is shown in Figs. 1 and 2, which indicate the number of papers in the field of pure chemistry that appeared in the aforementioned periodicals in each 10-year period from 1920 to 1952.

It should first be mentioned that Fig. 1 shows that the total number of papers concerning pure chemistry has nearly doubled in each 10-year period. During the period 1940–1952, Japan was under the influence of World War II and its aftereffects, and consequently chemical research in that period was depressed. Nevertheless, it is clear from these figures that research activity has recovered quickly in the past several years. The rapid increase in the number of papers is, however, mainly due to the fact that the results of research, the publication of which was suspended for a while after the war, have been accumulated. It should also be pointed out that papers have become generally shorter as well as more diversified than those published before the war. It is remarkable that the rate of increase in the number of papers in pure chemistry is parallel to that of industrial production, which has been increasing at the rate of nearly 10 percent per year. This suggests that the development of industry and the advancement of research in pure chemistry are closely related to one another, although research in pure chemistry is carried out with a greater degree of freedom. Nevertheless, it cannot be denied that the present situation of research still has many difficulties in comparison with the prewar situation.

In Fig. 2 it can be seen that the rate of increase of the number of papers in physical chemistry and in inorganic and analytic chemistry is comparatively greater than the rate of increase in the number of papers in organic and biological chemistry. This may be the result of the following situations. (i) In physical chemistry, some areas of research, such as structural chemistry, have been actively developed since World War II, and a fairly large number of theoretical works have been published besides experimental ones. (ii) The field of inor-

ganic and analytic chemistry now includes the section of geologic chemistry; this has resulted in an increasing number of papers.

Physical Chemistry

It was toward 1920 when the foundation of physical chemistry in Japan was laid by senior researchers, namely Joji Sakurai, Kikunae Ikeda, Yukichi Osaka, Masao Katayama, and others. Since that time, physical chemistry in Japan has developed normally. Although the number of researchers in physical chemistry is still comparatively small compared with that in other fields, the research problems cover many important areas. Thirty years ago the interest of Japanese physical chemists was mainly directed toward the classical theory of states of matter or the theory of chemical equilibrium, but, recently, interest has been directed toward the problems of molecular structure, chemical kinetics, colloids, high polymers, and others, parallel to the problems of general physical chemistry. This certainly corresponds to the development in these fields in other countries.

Among the problems of molecular structure, those concerned with the internal rotation and the nuclear vibrations in some simple molecules have been investigated in detail in both their theoretical and experimental aspects with many fruitful results, mainly by the group of physical chemists of Tokyo University. The study of the crystal structures of some organic and inorganic compounds by x-ray analysis has been carried out mainly at Osaka University. Other studies of molecular structure by the spectroscopic method, the electron-diffraction method, the magnetochemical method, and other methods have been made at the research laboratories of the universities of Kyushu, Nagoya, Tohoku, and others. They have all obtained many interesting results.

Recently, notable results have been obtained by some investigators in the study of the molecular structure of tropolones, seven-membered ring compounds. Physicochemical studies of the structure of protein molecules are also now being developed in connection with biochemical studies. Some junior physical chemists are interested in the problems of π-electrons in relation to photochemical reactions.

Relatively few researchers are working on chemical kinetics. The research group in the Institute of Catalysis of Hokkaido University is most active in this field. Many useful and fundamental researches on catalytic reactions have been carried out at the Hokkaido institute. A group of physical chemists in Kyoto University has long been interested in the study of explosions and reactions under high pressures. Recently, fundamental studies on polarography and the mechanism of electrode processes have been carried out by junior investigators with some notable results. The polarographic methods in chemical analysis, which were originally introduced into Japan 30 years ago by Shikata at Kyoto University, have greatly prevailed during the past several years.

Surface and colloid chemistry are also fields that are being developed in Japan with relatively strong activity. The Langmuir-Adam's surface balance has been successfully used by several investigators in some experimental work—for example, in the study of the thin films of proteinlike high polymers and in the study of the azoprotein films. The experiment and theory concerning the micelle formation of surface-active substances in their solutions have attracted the interest of many researchers in the field of colloid chemistry. Future development along this line is expected in connection with development in the applied field. Some colloid chemists have been interested in the study of abnormal viscosity or viscoelastic properties of dispersed systems (sol

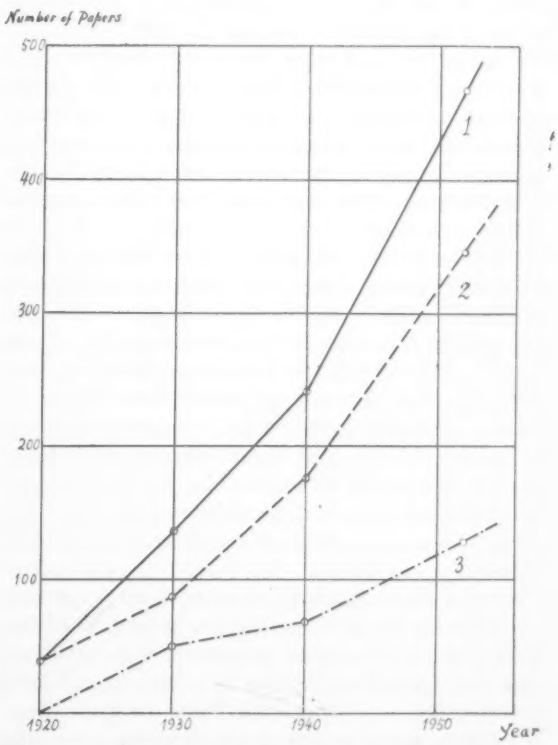


Fig. 1. Rate of increase in the number of papers in pure chemistry between 1920 and 1952; curve 1, total number of papers; curve 2, number of papers written in Japanese; curve 3, number of papers written in foreign languages.

or gel). These phenomena concern not only colloid chemistry but also rheology, a new science. A rheology group is being developed in Japan with colloid chemists as its nucleus. It is a noteworthy tendency that the chemists have come into active cooperation with the physicists and technologists in the borderline field of rheology.

Inorganic, Analytic and Geologic Chemistry

One of the notable results obtained in inorganic chemistry is thought to be that obtained in the study of the separation of nonradioactive isotopes that has been carried out mainly at Osaka University. Although the separation of deuterium in sufficient quantities for fundamental studies had already been made 20 years ago, this problem is now facing a new situation in relation to the atomic energy problem in Japan. There have been also some fundamental studies concerning the separation of heavy oxygen as well as heavy nitrogen, the latter of which has recently come to be sold in the market.

We have a tradition in the study of complex salts dating from the time 40 years ago when Y. Shibata initiated his research at Tokyo University. Especially in recent years, physicochemical study of complex salts has been carried out in addition to study of the formation of complex salts. The study of "salcomine" and other intramolecular complexes at Kyushu University is widely recognized. At the research laboratories of Osaka University and other institutions, some interesting results have been obtained in studies of the absorption spectra, dichroism, catalytic action, and crystal structure of certain metallic complexes.

The research in analytic chemistry, having a large number of works, covers both the fields of pure and applied chemistry. In Fig. 2, the statistics concerning applied chemistry are omitted. In applied chemistry, a study that largely depends on the equipment and apparatus available, Japanese chemists seem to have a great handicap in relation to the chemists in Europe and the United States, where striking progress has been recently made. The Japanese Society of Analytical Chemistry, an independent society, has recently been organized, and activity is expected in the future.

One of the characteristics of chemical research in Japan is the abundance of works in geologic chemistry. Such a trend may be natural because of the fact that Japan is a country of volcanoes and lakes and is surrounded by oceans. There are quite abundant data from studies of the eruption gases and sublimation products of various volcanoes and from studies of hot springs, mineral springs, subterranean waters, lakes, and oceans. The method in

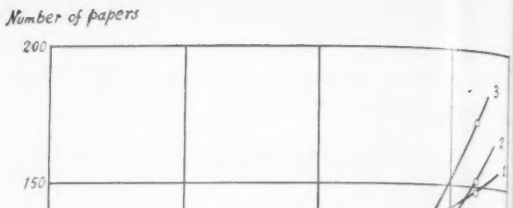


Fig. 2. Rate of increase in the number of papers in the sectional fields of pure chemistry between 1920 and 1952; curve 1, organic and biological chemistry; curve 2, physical chemistry; curve 3, inorganic and analytic chemistry.

research, however, has been mainly analytic-chemical, and some leading researchers have the opinion that no great progress in such a field as geologic chemistry can be expected until there is intimate cooperation among chemists, physicists, geologists, and biologists. For development of such cooperation, we must look to the future.

Organic Chemistry

The number of research projects in organic chemistry as a whole is certainly greater than the number in other fields of chemistry, for this field spreads over the sections of pharmacology and agricultural chemistry, both of which have independent organizations in Japan. Research in organic chemistry, which has been fostered by senior investigators such as U. Suzuki in vitamins, Y. Asahina in lichens, and T. Majima in alkaloids, now continues its steady progress. Despite the difficult postwar situation, some excellent work has been done in which the skill and intuition of Japanese chemists seem to have played an important role in getting fruitful results.

As one of the remarkable contributions, I must first mention the study of "hinokitiols" that has been carried out at Tohoku University. This study is widely known as having precedence in the chemistry of tropolones. In addition to this, studies on

the syntheses of polyenes having conjugated triple bonds, syntheses of santonin isomers, syntheses of kynurenine derivatives, and others, are also important contributions. Although research in organic chemistry is advancing rapidly, some leading organic chemists are not optimistic about the present situation of research in Japan because the tempo of progress is so rapid in Europe and the United States.

The study of the syntheses of high polymers may be included in the field of organic chemistry, but this study is mainly carried out by chemists in the applied fields. Some investigators in pure chemistry are making contributions to the study of the mechanism of polymerization reactions. Generally speaking, interest in the chemistry of high polymers has been greatly increased in recent years. The Society of High Polymers, which was established in 1954, is now quite active in advancing knowledge and research of high polymers both in pure and applied chemistry. It must be noted here that some theoretical physicists have also directed their interests to the problem of high polymers.

Biological Chemistry

Interest in and concern with biological chemistry have increased rapidly in recent years. Until 10 years ago, very few graduates from the universities were specialized in this field, but at present, the number of its students is comparable to the number in organic, inorganic, or physical chemistry, if it is not larger. Such a situation has undoubtedly been brought about by the exciting world-wide progress of biological chemistry. Research in biological chemistry in Japan has long been carried out in the various sectional fields of medicine, agriculture, pharmacology, and biology besides pure chemistry, but today, these sections are unified into an organization, the Japanese Biochemical Society, which greatly helps to make interconnections between these sections and to promote research.

The study of enzymes is no doubt a very important problem in biochemistry. Systematic studies on sulfatase, the enzyme that decomposes organic sulfates, have been carried out in Tokyo University. Studies concerning the metabolism of some microorganisms and photosynthesis have been made for many years in Tokugawa Biological Institute in Tokyo, the contributions of which have been widely recognized. Both Osaka and Nagoya universities are now becoming outstanding research centers in the study of nucleic acids and proteins. It can be seen from the subjects of discussion and symposia of the Japanese Biochemical Society that the main interest of Japanese biochemists is now directed toward problems in nucleic acids, serum proteins, phosphoric acids, and lipids. Biochemistry is still young in Japan, but it is expected that the output of research will increase rapidly in the near future.

Pure Chemistry and Industry

In recent years, the necessity to maintain a closer connection between pure chemistry and industry has been strongly recognized by leading chemists. From this standpoint, too, the Chemical Society of Japan has played an important role, for this society has been in a favorable situation to promote the cooperation of pure and applied chemists in the same organization. Nevertheless, such cooperation is still unsatisfactory because most pure chemists seem to prefer to concentrate their investigations on their own interests without giving attention to problems in applied chemistry. The problem of how to orient fundamental research in chemistry from the standpoint of the development of industrial manufacturing of this country has not yet been solved.

Meetings and Symposia

The Chemical Society of Japan has its annual meeting in April every year. At recent meetings, more than 1000 papers have been presented in the fields of both pure and applied chemistry. These papers are usually read at more than 10 sectional meetings in pure chemistry and at more than 15 sectional meetings in applied chemistry, and the whole meeting lasts from 4 to 5 days. At present, only the cities of Tokyo and Kyoto have enough capacity to hold such a large-scale meeting. Therefore, the annual meeting is held in Tokyo or in Kyoto from year to year according to the schedule of twice in Tokyo and once in Kyoto. The huge number of the papers presented at the meeting can be considered as a measure of the research activity of Japanese chemists, but some leading chemists have the opinion that the papers should be more thoroughly selected before they are allowed to be presented to the meeting. Moreover, it is not an easy problem to decide how to organize efficiently such a large-scale meeting.

Recently, in addition to the annual meeting of the society, a discussion or symposium is usually held once or twice a year in each sectional field of chemistry—for example, in structural chemistry, colloid chemistry, chemistry of high polymers, geologic chemistry, analytic chemistry, and organic chemistry. These discussions or symposia, which are sometimes held at places other than Tokyo or Kyoto, are usually concerned with particular topics. They are accompanied by introductory lectures on

the topic being discussed. The main purpose of the discussions and symposia is to give researchers a chance to communicate their recent activity and, at the same time, to exchange knowledge among themselves for cooperative works. Such discussions or symposia have been very successful, but they are not yet quite free from the danger of falling into mannerisms. Some researchers consider that the society should have permanent sectional committees in its control for the effective planning of symposia and discussions.

International Exchange of Knowledge

The international exchange of knowledge has become more active in recent years in the field of chemistry as well as in other fields of natural sciences. The Japanese chemical societies are connected with the International Council of Scientific Unions (ICSU) through the Japan Science Council (Nippon Gakujutsu Kaigi), the Chemical Research Liaison Committee of that council being in charge of the actual management. This committee takes part in the election of representatives for the conference and congress of the Union of Pure and Applied Chemistry (UPAC), of which Japan is now one of the members, as well as for other international meetings.

Japan has not yet had a chance to organize an international conference or congress in chemistry in her own country. Japanese chemists are, however, expecting to hold one in the near future. Some prominent foreign chemists have come to Japan during the past 3 years either as guests or for research. In 1953, R. Robinson of England, W. Reppe of Germany and G. Egloff of the United States came as distinguished guests at the 75th anniversary of the Chemical Society of Japan. Recently, F. Daniels, H. Brown, and L. Pauling of the United States, A. Butenant of Germany, and B. Breyer of Australia visited us for a short stay. The lectures and conferences given by such distinguished foreign scholars resulted in great success in promoting mutual understanding and in stimulating the younger chemists of Japan.

Chemical Education

As a result of the reformation of the Japanese educational system after World War II, the problem of chemical education in colleges and universities has become a matter of discussion. It became also an important problem how to provide education for postgraduate students in chemistry under the new system of graduate schools.

Japan has adopted the following educational system: 6 school years of primary school; 3 years of junior high school; 3 years of senior high school; and 4 years of college or university. On this basis, graduate schools of 2- to 5-year curriculums are being established. The teaching of chemistry as an independent subject in senior high school is parallel to the teaching of other natural sciences—namely, physics, biology, and earth science. These subjects are elective, and any two of these four subjects are required for entrance to colleges or universities. College professors sometimes receive students from high school who have not taken chemistry in high school. Moreover, the course of chemistry as specialized education in colleges and universities is generally not as far advanced as it was in the prewar system of 6 years of primary school, 5 years of middle school, 3 years of high school, and 3 years of college or university, in which students could finish an introductory or preparatory course of chemistry at high school before they entered university. In the new system, some parts of advanced courses in physical, inorganic, and organic chemistry must be transferred to the graduate course.

There are 229 4-year colleges and universities in Japan at present, of which about 40 institutions have courses in pure chemistry, about 50 have courses in engineering chemistry, and about 30 have courses of agricultural chemistry, and about 25 have courses of pharmaceutical chemistry. The total capacity of these institutions for students is about 22,000. There are nine governmental universities, two public universities, and three private universities which have graduate courses in pure chemistry; eight governmental, two public, and three private universities have graduate courses in engineering chemistry; five governmental universities have graduate courses in agricultural chemistry; and five governmental universities have graduate courses in pharmaceutical chemistry. The number of students allowed in these institutions is about 1500 on the whole.

Most students who graduate from the 4-year undergraduate course in chemistry enter chemical factories. However, those who want to become research chemists or college professors enter graduate schools. The ratio of the latter students to the former is different in pure and applied chemistry, the ratio for pure chemistry being generally large in comparison with that for applied fields.

In prewar time, many Japanese chemists were sent abroad as research fellows of the government. Such governmental fellowships, which were interrupted during war and postwar time, have recently been revived, but the number of researchers who receive fellowships is still very small. Private institutions themselves can almost never afford such

fellowships. Consequently, for professors in colleges and universities, the chance to go abroad by the help of the national fund is at present very small in comparison with that in prewar time. However, many other countries now offer national fellowships or scholarships for foreign scholars and students, and these provide Japanese chemists with another way to go abroad for study and research. Because these scholarships generally put a certain limitation on the age of applicants, junior researchers have much advantage over senior ones in obtaining them.

The Ramsay memorial fellowship of the British Government, which is awarded to a young chemist under the age of 30, has been revived since 1953. The applicants for this fellowship are examined and chosen by the Chemical Research Liaison Committee of the Japan Science Council every 2 years. Several chemists every year are awarded American scholarships to study in the United States under the Fulbright-Smith-Mundt Act.

It is highly desirable that more such international scholarships be made available to able younger chemists in Japan.

The Chemical Society of Japan is not indifferent to the problem of chemical education. The society has organized a special committee for chemical education under the auspices of which annual symposia have been held. To date the problem of teaching chemistry in high school as well as in college freshman courses has been the main subject of discussion. Through such symposia, the importance of the problem of chemical education has been fully discussed. The symposia have been published and distributed by the society. It is hoped, however, that the society can establish a journal on chemical education, similar to the *Journal of Chemical Education* of the American Chemical Society, in the near future.

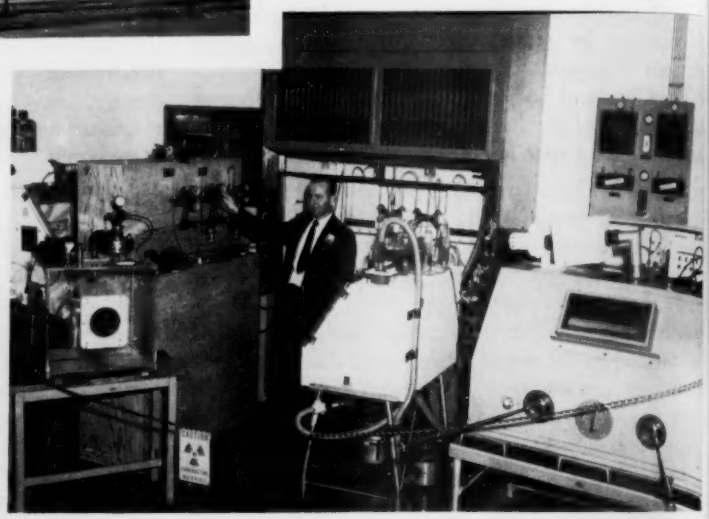
The Chemical Society of Japan is also active in the popularization of chemical knowledge. For that purpose, local sections of the society have occasionally presented popular public lectures. As one of the memorials of the diamond jubilee, the society presented popular lectures by specialists in each field of chemistry and an exhibition on the Japanese chemical industry, the latter of which achieved an especially good reputation. As one of the activities of the society, we can further mention the publishing of the *Chemical Library* which was designed several years ago as a series of standard reference books for high school and college students. Nine books have already been published.

SCIENCE ON THE MARCH

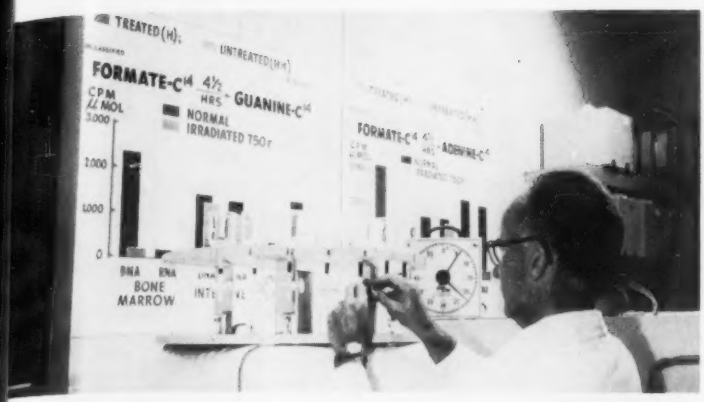
Radiological Defense Laboratory

The U.S. Naval Radiological Defense Laboratory in San Francisco, California, was moved last year into a new six-story building (left) on a site overlooking San Francisco Bay. The laboratory was established in 1946 to make radiological studies of the Bikini test explosions, and it was then housed in two small buildings in San Francisco Naval Shipyard. One of its first problems was to develop a method for decontaminating the target ships. By 1954 the laboratory occupied 20 widely separated buildings.

Some of the research conducted at NRDL is concerned with the harmful effects of various types of nuclear and thermal radiations. Modern apparatus is used to confine radioactive materials while experiments are in progress (right).

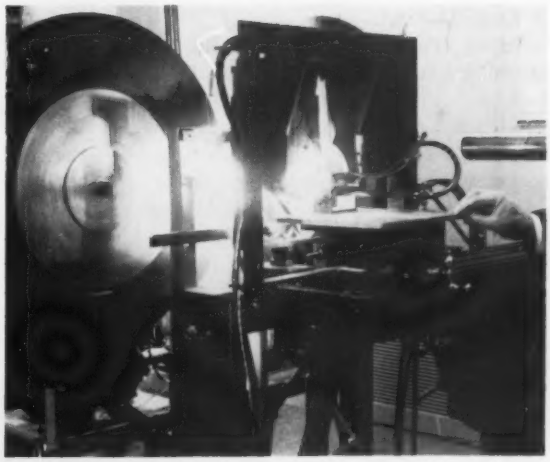


Among the large pieces of experimental equipment available to laboratory personnel are various radiation sources, including several x-ray machines and an 8-curie cobalt source. A 40-channel gamma-ray analyzer (left) is used to measure radioactive fallout products. A 2-Mev Van de Graaff generator, the high-voltage end of which is shown (right), is equipped for acceleration of both electrons and nuclear particles. The generator is housed in a separate building on the same site.



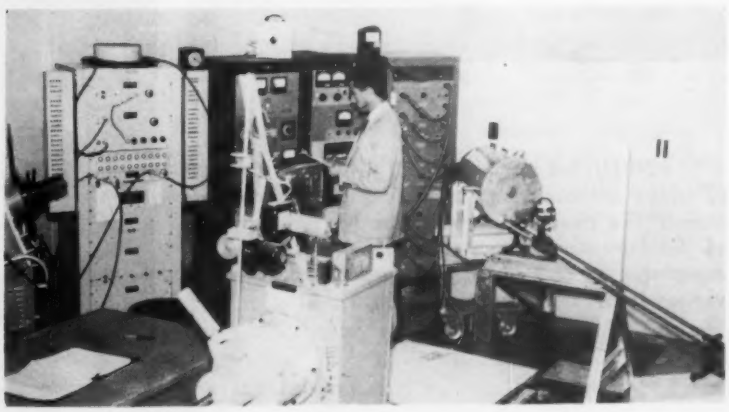
The laboratory has three departments: administrative, medical, and scientific. The scientific department is headed by a civilian. One of its four technical divisions, the biological and medical sciences division, is concerned with the effects of nuclear and thermal radiations on human beings and animals. Radioactive tracers are used to study the physiological changes induced in animals by radiation (left).

One piece of equipment that can be used for studies of the effects of thermal radiation is a device that simulates in the laboratory the heat pulse from an atomic bomb (right).

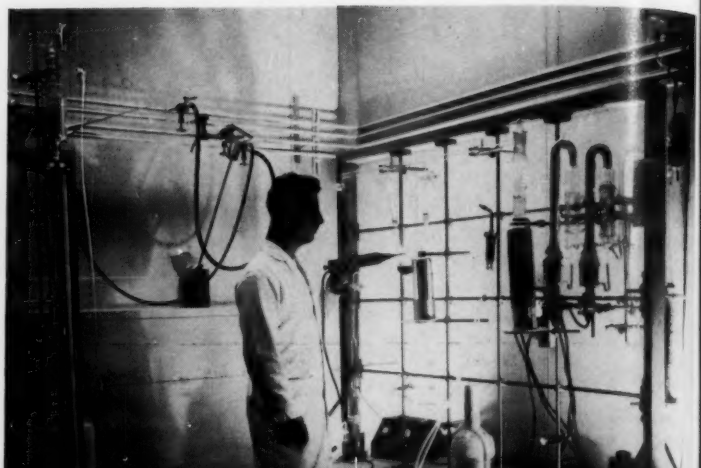


Mice are exposed to radioactive fallout simulants in an inhalation chamber (left). Other available equipment includes several climate-simulating chambers ranging in size from small units to walk-in types. For work with high-level radioactivity, there is a change house and a hot cell with special shielding and provisions for waste disposal.

The second technical division of the scientific department is the nucleonics division, which investigates the characteristics of nuclear and electromagnetic radiations and designs and develops instruments for detection and measurement. Electronic equipment is used to measure the energy and direction of cobalt gamma rays after the rays have penetrated thick steel barriers (right).

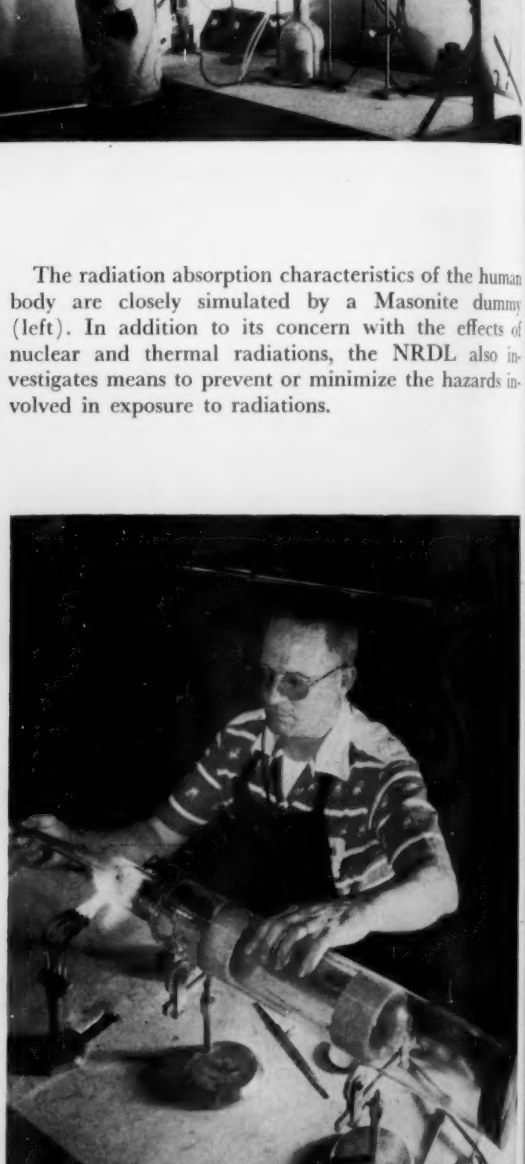


The chemical technology division is the third technical division of the scientific department. It conducts investigations of radioactive contamination of ships, aircraft, equipment, and other objects, and it develops methods of decontamination. Its work requires extensive study of the basic chemical and physical nature of radioactive substances. A glass high-vacuum system is used to study the decomposition of materials by radiation (right). The fourth division of the scientific department is the military evaluations group. It interprets and adapts knowledge of radiation effects to the needs of the armed forces.



The radiation absorption characteristics of the human body are closely simulated by a Masonite dummy (left). In addition to its concern with the effects of nuclear and thermal radiations, the NRDL also investigates means to prevent or minimize the hazards involved in exposure to radiations.

The NRDL has a staff of about 600, more than 300 of whom are classed as scientific and technical personnel. The remainder support the research activities of the laboratory. Many types of intricate scientific equipment are constructed in the glass shop for use in various laboratory experiments (right).



LETTERS

Our Vanishing Sea Turtles

The status of the sea turtle today is comparable to that of the American bison in the nineties. Uniform legislation and an awakened sense of the interest-value of these creatures is all that can save the remnant from extinction. Unfortunately their commercial value along our shores is insufficient to obtain the backing of business for their protection. The turtles' greatest value today is the pleasure given to travelers who love to see life on an otherwise empty ocean and the satisfaction that all citizens should feel in the knowledge that another harmless member of our heritage has been saved from the fate which befell the great auk, the passenger pigeon, and the Carolina parakeet.

According to replies received from fish and game departments of South Atlantic and Gulf states, supplemented by copies received of the game laws of these states, the status of sea turtle regulation as of 1951 is as follows: Georgia and South Carolina give total protection; Florida protects turtles "while out of water" during the period from May to August, but the eggs and nests are protected in Dade and Martin counties only; Texas provides virtually no protection; and Virginia, North Carolina, Alabama, Mississippi, and Louisiana offer no protection whatsoever. Clearly a more uniform effort to provide safeguards for sea turtles is essential if protection of the species is to be successful. Not only could the proper sort of legislation be enacted, but propagative measures of at least a limited sort could be adopted.

Legislation must be realistic. The species or "classes" as well as sex of turtles should not be differentiated. The term *any sea turtle* should be adhered to, because the miscreant will otherwise claim ignorance where lesser penalties might be attached according to species or sex. The magistrate also may not be able to differentiate.

Capturing any turtle on beaches should be a misdemeanor. Unfortunately, this law would be practically impossible to enforce with much success. As a consequence, the penalty should be the maximum possible.

Turtles under or over a certain size should be rigidly protected. It is a waste to destroy the small because the amount of food secured is insignificant. Very large turtles should be protected because their reproductive value exceeds their food value. Very large and small lobsters are similarly protected, and the same reasoning applies to turtles.

The method of measurement should be clearly stated. The legal size of a turtle should be determined by measuring with a tape line from the front of the upper shell or carapace, at the region of the neck, over the curve of the back to the rear end of the upper shell.

Perhaps, because of years of illegal capture of females on beaches, the male population exceeds the female. The excess of males is to some extent compensated by the "buck" netters who fashion a heavy plank to roughly resemble a turtle and anchor it with a short piece of net attached. The male, which will try to mate with any floating object, becomes entangled in the net. The catch by these fishermen is consequently almost exclusively of males. The fact that males exceed females in number causes pelagic fishermen to capture an excess of males, but this obviously cannot change the proportion. The netters who string nets across sloughs or elsewhere near shore catch an excess of females. The only bright spot in the picture is that, with all turtles scarce, the excess of males helps to insure fertile eggs.

All turtle catchers should be licensed, and the length and mesh of nets should be standardized. Nets across sloughs or along the shore should be prohibited. Turtle canneries and purveyors of their flesh should be licensed and closely inspected for infractions.

There should be a closed season for all turtles, coinciding with the laying season.

Provision should be made for maintenance of study and the collection of turtles for scientific purposes.

Preservation of the sea turtles probably will not be accomplished solely by legislation. Some sort of propagative aid should be provided. Three means are suggested: establishing reserve areas; collecting hatchlings and placing them in protected areas; and collecting eggs and hatching and rearing the young in a supervised locality. Here again the difficulty and expense of enforcement is the great handicap.

The most obvious and possibly the most readily controlled areas would be those near lighthouses, Coast Guard stations, and similar areas already under possible supervision. Safeguarding nesting turtles should be a regular duty of personnel employed there. The next best would be the regular patrol of suitable beaches during nesting periods. The areas would have to be posted and effectively patrolled. Infractions would have to be severely dealt with.

Hatching and starting would be by far the best

means of aiding propagation. This would require screening off suitable lagoons where the hatchlings could be guarded for a year before they were released into the ocean. It would be a waste of time to dump hatchlings into the sea. The mortality by birds and fish is too great.

Natural nests could be surrounded by wire mesh and the hatchlings gathered and taken to the starting lagoons, or eggs could be gathered and hatched at a station contiguous to the starting area.

To save our marine turtles from extinction legislation must be enacted to make it illegal to take turtles less than 2 feet long or over 3½ feet long. Propagative aid should be provided by screening starting ponds where hatchlings may be protected for at least 1 year before release.

CHAPMAN GRANT

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Documentation in the Service of Science

Documentalists will resent the accusation that they have complained that too much technical information is being produced [see *Sci. Monthly* **83**, 82 (1956)]. The reader is thereby given a completely erroneous impression of a professional group that has pioneered in promoting the increased utilization of scientific information through modern methods of dissemination and retrieval. Saul Herner's criteria for differentiating documentalists from librarians are not only inaccurate but also strange for a member of the American Documentation Institute. The use of quotation marks to characterize documentalists is equally strange. Herner's optimism about the state of scientific documentation will not aid the abstracting services, which must contend with the increasing volume of scientific publication. Nor will it help the scientist when he uses the indexes, which grow larger and more difficult to use each year.

Space and time do not permit me to comment in detail upon some of the contradictory and/or more laudable statements in this paper. For the record, let it be known that documentalists have nothing to lose and all to gain by an increase in scientific publication, which increases the need for their services. Documentalists are striving for increased use of technical information. They are seeking and finding instrumentalities for increasing the productivity of the scientist by making data as easy to find in the literature as it is to produce in the laboratory. As the forerunner of scientific intelligence, modern creative documentation leads to an ever-increasing volume of technical information, a development that both scientist and documentalist will applaud.

EUGENE GARFIELD

Woodbury, New Jersey

The editorial office of The Scientific Monthly *is responsible for the insertion of the quotation marks around the word documentalist in the sixth paragraph of Herner's article.*

Pseudonyms

Concerning "Pseudonyms of physicists" [*Sci. Monthly* **83**, 130 (1956)], Robert Lagemann supposes that the anagram "Rednaxela Gnimelf" by Alexander Fleming, the Scottish mathematician, is a "fantastic pseudonym." However, inspection of this anagram shows it to be a simple reversal of the spelling and capitalization of each part of the mathematician's name without a reversal of the positions of the personal and familial portions of it.

ROBERT C. MILLER

Wahiawa, Oahu, T.H.

BOOK REVIEWS

Report of the Special Committee on the Federal Loyalty-Security Program of the Association of the Bar of the City of New York. Dodd, Mead, New York, 1956. xxvi + 301 pages. $5.

This is an important book on a subject that intimately affects the lives of more than 5 million American citizens who, directly or indirectly, work for the government. More than 2.3 million are federal civilian employees, and nearly 3 million more are civilians engaged on defense contracts which involve access to classified information. Add the wives and children of all these workers, and it is plain that the question of whether the federal loyalty-security program is planned and administered wisely or badly concerns at least 10 percent of the population of the United States. It is of especial interest to scientists, thousands of whom are doing research on government projects in public and private laboratories.

This report carries great weight because of the distinction of the men responsible for it and the thoroughness and dispassionate spirit with which they performed their task. It was initiated by the foremost bar association in the country, the Association of the Bar of the City of New York, which has repeatedly shown a strong sense of responsibility in its reports on public questions. The devotion of its members to their country is unquestioned, but they have steadfastly insisted on examining measures against Communists and other radicals with lawyerlike judgment, instead of approving them in outbursts of undiscriminating patriotism, regardless of effectiveness and fairness. During the hysteria of the Red Menace this association backed Charles Evans Hughes in opposing the expulsion of five duly elected Socialists from the New York legislature; and in 1951, its committee published urgent objections against the hastily adopted resolution of the American Bar Association requiring every lawyer to take an annual loyalty oath over and above his solemn pledge on admission to the bar that he would support the Constitution and faithfully perform his professional obligations.

On the present occasion, the association wisely decided not to entrust the study of this momentous nation-wide question to New York lawyers alone. So it set up a committee of nine lawyers, five from its own membership and four leaders of the bar in Chicago, Los Angeles, New Orleans, and Washington. From New Orleans, for example, it chose Monte Lemann, the only member of the Wickersham Commission under President Hoover who had the courage to recognize that prohibition had failed. The chairman of the present committee is Dudley B. Bonsal of New York; hence, this book is commonly called the Bonsal Report. The committee retained an able research staff comprising Elliott Cheatham of Columbia Law School, Jerre Williams of the University of Texas Law School, and two practicing lawyers from New York and Philadelphia.

The committee derived its data from three main sources. First, it examined and clarified the complex legal mass of Acts of Congress, Executive Orders, and departmental regulations. (These are largely reprinted in a long appendix.) Second, it reviewed published information about the administration and operation of those laws. In addition to government reports and Congressional hearings, the most important previous books appear to be two. Eleanor Bontecou's Federal Loyalty-Security Program (1953) in the Cornell Studies in Civil Liberty, is necessarily confined to events under President Truman. *Case Studies in Personnel Security* (1956), directed by Adam Yarmolinsky, presents 50 selected cases as seen by the employees and their counsel. No similar material from the government side was available, because security files and decisions are treated as confidential. Third, the committee consulted about 150 persons who knew the subject at firsthand. These conferees, whose names and qualifications are listed, include officials of the national government, such as Attorney General Brownell, Scott McLeod, security officer for the State Department, and Philip Young, chairman of the Civil Service Commission; counsel and staff members of Congressional investigating committees; leaders of business and labor and of universities and research institutions who have observed the impact of the programs; lawyers who have acted for the government or for employees in security cases; informed and thoughtful supporters and critics of the loyalty-security programs. This admirable, wide range of personal contacts gives much force to the conclusions reached by the committee.

The Bonsal Report should not be confused with a different report on the same subject which is still in process. In August, 1955, a Joint Resolution of Congress created a bipartisan Commission on Government Security with 12 members, four appointed by the President, four by the Vice President, and four by the Speaker of the House. The chairman is Loyd Wright, a former president of the American Bar Association. It includes Senators Norris Cotton and John Stennis, Representatives William McCul-

loch and Francis Walter, and eight private citizens. The list would be more impressive if it had one well-known supporter of individual liberty, such as John Lord O'Brian. Still, this group has the prestige of being official. Let us hope that, unlike the Wickersham Commission, its conclusions will not be warped by political pressures. It will be interesting to see how far its recommendations, when published, coincide with those in the Bonsal Report.

Readers who are not specialists in the loyalty-security program will find it unnecessary to go through the whole 188 pages of text of the Bonsal Report. Great as its merits are, much of it is hard sledding. There is none of the human interest that comes from individual cases. The authors were probably wise in omitting these entirely, since they could have given only one side of any case, with all access to government records denied. Nevertheless, it is difficult for the mind to bite into discussions consisting solely of general statements. Consequently, I venture to suggest the portions that deserve the most attention, especially from scientists.

A very convenient summary of 15 pages at the outset gives the main findings and the text of the recommendations. However, I urge any scientific reader who can spare the time not to stop here but at least to go over the last two chapters (68 pages). Here he will find measured judgments on the achievements and the intangible costs of the program (chapter VII), and an interesting exposition of the reasons for the various recommendations (chapter VIII). In addition, he will do well to read the three introductory chapters (28 pages), which put the loyalty-security program in its full setting. Chapter I presents in thoughtful and sometimes eloquent language the two conflicting policies of liberty and security, both of which should be steadfastly kept in mind. Chapter II deals with the Communist threat and shows how the recently altered character of this threat requires reexamination of programs established 10 years ago, in order to meet the conditions of today. Chapter III, on countermeasures by the United States, makes it plain that the personal security programs are only one segment of many measures guarding our nation and, therefore, should not receive excessive emphasis. The following quotations from this chapter exemplify what I have called the measured tone of the authors of this report:

". . . in planning for national security, it is not enough to consider security alone. It is essential that account be taken of our democratic traditions of liberty and fair play. If, in the long-range planning, these traditions were to be ignored or if, in the long-sustained period of stress, they were to be consistently violated, they might be permanently warped and impaired. That would itself be a victory of a sort for our opponents in their fight against our liberty. We must never forget that the very purpose of national security is to preserve our independence and liberty and not merely to combat the greatest present danger to it, Communism. . . .

"The security of the United States depends ultimately on the strength of the nation. It cannot . . . be the result of a single simple measure. The components of national strength are numerous. No one of them should be seen in isolation. . . ."

The portions just specified (less than 111 pages) will give any scientist an adequate understanding of the Bonsal Report. He can then dip as much as he finds profitable into the central portion of the book, which seeks to present with painstaking accuracy the unbelievable complexities of the existing situation. The seven different personnel security programs applicable to civilians, with still another for the armed services, are described in chapter IV. Then the structure and stages of the programs are reviewed in chapter V, which sets forth substantial variations in official methods, not only at different dates, but also among the seven programs and among the various departments and agencies subject to a particular program. In spite of the valiant efforts of the committee to show just what is going on, only the clearest-headed reader can avoid vertigo. Finally, a short chapter (VI) presents the size and monetary costs of the programs—$160 million to the taxpayers since 1955. This does not count what defense industries spent in clearing employees or the lawyers' bills of accused workers.

Before saying a little more about the last two chapters—the best part of the book—I ought to mention two unsatisfactory points in the report. First, the list of criminal statutes against treasonable and subversive activities omits the very important Act of 1861, which severely punishes conspiracies to overthrow the government by force or forcibly to hinder the execution of any federal law. This act renders protection against really dangerous federal employees stronger than the committee makes it out. With such a weapon against bad acts at its disposal, the nation would not (as is often stated) be helpless if we had not adopted since 1940 all the loyalty programs and sedition statutes and other measures against bad talk, bad associations, and bad thoughts.

Second, the report does not make it sufficiently clear that the withdrawal of any given group of civilian employees from summary removal under the loyalty-security programs does not prevent the government from discharging any actual spy or saboteur or betrayer of official secrets. For decades a procedure has existed for getting rid of a federal

employee whose unfitness is proved, and this procedure is available today if he is exempt from the loyalty-security programs. The Supreme Court emphasized this important point last spring in *Cole v. Young*, which held the programs inapplicable to federal employees outside the Department of Defense, the State Department, and other agencies expressly mentioned by Congress when it authorized the present programs in 1950.

The correction of these two slight shortcomings strengthens the committee's position that we can trust ordinary laws to safeguard the nation for the most part and use loyalty-security programs to counteract the special risks inherent in sensitive government jobs.

The sober judgment of the committee is well shown in its conclusions about the achievements and intangible costs of the program (chaper VII):

"The nature and the extent of the achievements of the [loyalty-security] program cannot be precisely determined. The program is preventive in its purpose, and in the nature of things it is impossible to know exactly what was prevented, that is, what would have occurred if the program had not existed.

"Similarly, the intangible costs of the program . . . cannot be fixed with exactness.

"It is probable that some undesirable and even dangerous persons have been ousted or barred from employment in Government or industry. It is likely that important scientific and technological developments have been withheld from an aggressive enemy, but the consequent slowing down of his potential for aggression was of short duration. It seems clear that the reputation of the Government service has been cleared of the imputation of grave subversive infiltration, with improvement of the morale of some of the employees. Similarly, it is suggested that the security clearance has somewhat facilitated the prompt operation of the work of the Government.

"On the other side of the balance, there has probably been some impairment of positive security through the slowing down of scientific and technological advancement. There has been an injury to our international repute and security from the maintenance of a system which seems to our friends abroad to go beyond the true needs of national security. There has probably been some injury to the morale of the government service and certainly needlessly severe burdens to a considerable number of individual employees who have been unnecessarily suspended, tried and subsequently cleared. And there is some evidence of a general blunting of our national concern with freedom of speech and fair hearings, although that is clearly on the rise again."

"What then should be done?" the committee asks. It agrees with almost all of the conferees that there is need for a personal security program, but it believes that improvements can and should be made. The recommendations for changes in the 52 pages of the very interesting final chapter of the report are designed to overcome the main weaknesses which elsewhere (page 6) the committee found in four aspects of the program. I shall state each weakness and then briefly mention some of the changes that are urged to meet that weakness. My presentation merely scratches the surface of the chapter, and I hope that scientists will dig out its valuable material for themselves.

1) "There is a lack of coordination and supervision of the various personnel security programs."

The very first recommendation of the committee attacks this weakness by recommending a director of personnel and information security in the Executive Office of the President, with power to make regulations which, when approved by the President, shall be binding upon the departments and agencies concerned.

Scientists will be greatly interested in one power to be conferred on this new director. They have been badly hindered in their researches by the overclassification of documents and also by the tendency to prolong classification long after disclosure has ceased to be harmful to public safety, largely because nobody in the government has any vital urge to interrupt new work in order to weed out old classified documents. All this, the committee points out, is deeply injurious to national security. It quotes Dean Van Vleck of Harvard: "The moment we start guarding our toothbrushes and our diamond rings with equal zeal, we usually lose fewer toothbrushes but more diamond rings." Therefore, scientists should be pleased by the recommendation that the director will continuously review the standards and criteria and methods to be used in classification and declassification of information; he will make recommendations to the President on both matters and, with his approval, impose those recommendations to bind the departments and agencies involved.

Another coordinating reform proposed is a central screening board in the Civil Service Commission, which will have the responsibility of determining whether or not security charges ought to be filed against any person covered by any security program, either a federal employee or a private defense worker. This change will check what the committee considers to be "excessive filing of charges." The change, however, is not to apply to the Atomic Energy Commission or the Department of Defense.

2) "The scope of the personnel security programs is too broad in that positions are covered which have no substantial relationship to national security."

Consequently, the committee recommends that "clearance . . . should be required for all sensitive positions and for no others." This is the most drastic reform in the report. After the book went to press, it was substantially carried out by the Supreme Court in *Cole v. Young*. The committee's solution differs, however, in one important respect. It would base the applicability of the loyalty-security program on the nature of the work of the individual and not on the blanket nature of his department or agency. The proposal is that the head of each department or agency is to designate as "sensitive" only those positions whose occupants will have access to "secret" or "top-secret" documents or will have a policy-making function that bears a substantial relation to national security. Thus a bootblack in the Pentagon will be exempt, although now he has to be investigated by the FBI.

Earlier this summer it seemed probable that Congress would rush through one of the bills intended to supersede *Cole v. Young* without paying any attention to the Bonsal Report. Fortunately, Congress adjourned to attend the conventions. By the time it reconvenes, both this report and that of the official Commission on Government Security will be available for careful study by Congress and the President. No doubt, the Constitution allows them to undo *Cole v. Young*. Yet the report states an important general principle:

". . . to say that a proposed measure is constitutional is not to say that it is either wise or just. The inquiry remains . . . what do the security and welfare of the country and the liberty of its citizens call for. The answer to this inquiry can be given only by the [executive and legislative] branches of the Government."

3) "The standards and criteria do not sufficiently recognize the variety of elements to be considered, including the positive contribution which an employee may make to national security, and they do not readily permit a common sense judgment on the whole record."

The test now in force for rejecting an applicant or discharging an employee is "whether the employment of the person is clearly consistent with the interests of the national security." A statement by the Los Alamos chapter of the Federation of American Scientists observed: "In granting clearance to anyone there is always involved a calculated risk, but . . . in the past the calculation has given the greatest weight to the negative aspect of keeping secrets inviolate and very little weight to the positive aspect of keeping ahead of our competitors by means of fresh ideas and positive achievements." The committee substantially agrees, remarking:

"In the hands of an unduly literal minded hearing board or administrator, the '*clearly* consistent' test may produce results contrary to common sense, unfair to the employee, and opposed to the long-range interest of the nation."

Therefore, the committee sensibly recommends an entirely new test: "The personnel security standard shall be whether or not in the interest of the United States the employment or retention in employment of the individual is advisable. In applying this standard a balanced judgment shall be reached after giving due weight to all the evidence, both derogatory and favorable, to the nature of the position, and to the value of the individual to the public service."

Besides urging this change in the test, the committee is very critical of the Attorney General's list of subversive organizations, membership in which has often been a decisive factor in the condemnation of an actual or prospective employee. It recognizes, indeed, that "A person's associations are clearly relevant both to his own motivations and to his susceptibilities to outside pressures. Associations are taken into account as a matter of course in determining suitability for other employment. It should not be otherwise when security trustworthiness is involved." Nevertheless, the Attorney General's list has "serious weaknesses," which are pointed out, and there has been widespread misuse of it, in federal personnel inquiries and by states, cities, and private employers. Therefore, the committee recommends that the list be abolished, unless it can be and is drastically modified in several specified ways.

The suggested changes are excellent, but I doubt that they will cure the mischiefs of this list. Take, for example, the proposed requirement that only those organizations shall be listed which have been given an opportunity for a hearing. This would not help a large number of organizations on the list that were temporary committees to get signers for a single petition or to lobby for or against a single bill in Congress. A committee in this category spent all its funds, and, when the occasion was over, it disbanded. Who then is going to represent it at a hearing? Who is going to pay a lawyer? Yet anybody who took part on the committee will be blasted for years to come if it can be put on the list after taking no advantage of the opportunity for a hearing. I wish that the Bonsal Report had called for unqualified abolition of the Attorney General's list. In the famous words of Bottom, "Why not reform it altogether?"

4) "The security procedures fail in various ways to protect as they could the interests of the government and of the employees."

This point covers many important procedural problems, all ably discussed. I shall mention only three.

First, now, as soon as security charges are filed against an employee, his pay stops. If he is cleared, he may get back pay. Meanwhile, he has to hire a lawyer. Think what this would mean to any of you who read this review. It is punishment before trial. This inhumane practice would be wiped out by the committee. The pay of suspended employees should continue; and, if possible, an employee under charges should be transferred to a nonsensitive position instead of being suspended. Inasmuch as a high percentage of persons charged are ultimately cleared and given back pay, these recommendations would "entail only a small cost to the government" in return for greatly increased protection of individual welfare.

Second, the report recommends elaborate provisions for an employee to know the specific charges against him and meet his accusers face to face. Although exceptions are still allowed in the interests of national security, some improvement ought to result. Moreover, both the government and the employee would be entitled to subpoena witnesses and make them testify at a hearing, which is not now possible for either side.

Third, the present practice of repeatedly requiring an employee to face investigation is considerably stopped by the provision that new security proceedings should not be brought against the same person on the same facts, whether in the same agency or in different agencies. In the absence of new evidence, a security clearance will stand and is not to be reopened. The committee is not ready to grant quite such full protection against double jeopardy as in criminal cases after an acquittal. There the purpose, it says, is to prevent punishment for a *past* illegal act after the man has been once cleared of the accusation of having committed that act. By contrast, the government in a security case is endeavoring to protect itself from *future* betrayal by an employee. So the same considerations do not apply. If the employee is in fact a bad security risk, he ought to be barred from sensitive employment, even though he has been cleared earlier. Enough protection is given him if reopening is prohibited, so long as no new evidence against him is produced.

In discussing procedural reforms, the committee is mindful not only of present employees but also of applicants for positions. The government is harmed if it denies jobs to qualified persons on untenable grounds and baseless suspicions. The protection due to applicants is, of course, somewhat less, but the details are well worked out.

Some doubts and disagreements on particular points have not prevented me from feeling more and more admiration for the Bonsal Report while rereading much of it. Always conscious throughout of public dangers, the committee never loses sight of the blessings of liberty.

"For the United States to depart from its ideals to the end of supposed greater security would be to shift the contest to a level on which it cannot win. We can never equal the Communist countries in enforced internal conformity. Their history and efficiency in suppression and regimentation are abhorrent to us. If we engage them on that line, we shall lose. Our superiority, inside our nation and in the world contest, is in the liberty of our people and the initiative and resilience which liberty can bring."

ZECHARIAH CHAFEE, JR.
University Professor, Emeritus
Harvard University

Illustrations of the Huttonian Theory of the Earth. John Playfair. Cadell and Davies, London; Creech, Edinburgh, 1802. Facsimile reprint with an introduction by George W. White. University of Illinois Press, Urbana, 1956. 528 pp. $4.50.

To those who have never read this important work of Playfair, this facsimile reprint is very interesting and, as older printing goes, fairly easy to read, since type is larger than that in many 1802 books, although the archaic letter *s*, which looks like an *f*, is confusing at first. White's introduction gives a brief history of the writing of the *Illustrations* and also brief biographical sketches of James Hutton and John Playfair.

E. WILLARD BERRY
Department of Geology,
Duke University

Plane Trigonometry. E. Richard Heineman. McGraw-Hill, New York, 1956. v + 238 pp. Illus. $3.75.

The principal changes in the new second edition of this book are in the problem lists. The preface indicates that completely new problem lists appear in this edition, and that the number of stated problems has been increased appreciably. These

changes should make this textbook more useful to the teacher and student. Both editions of this book can be recommended for teachability, particularly for students with a weak mathematical background. The textbook can be appropriately used for trigonometry courses in high school.

Among the special features of this book are exercises containing true-false questions to test the students' ability to detect camouflaged truths and a careful explanation of approximations and significant figures, the principles of which are adhered to throughout the book. While the desirability of using true-false exercises may be questioned, they do seem to emphasize the need for accuracy in mathematical statements and for avoiding too easy generalizations. A third special feature worth mentioning are problems in which trigonometric functions are used as they will arise in the calculus. The definition of the trigonometric functions is given first for the general angle. The treatment in the text, in general, is traditional, but perhaps traditional in the most desirable sense.

The work on triangle solutions does not appear until Chapter XI, page 107. The material in this chapter is adequate, but most or all of it could well be omitted. More attention to the graphing of trigonometric functions would have been desirable. This is somewhat offset by a paragraph on sketching curves by composition of "y" ordinates, which is found in the appendix. There are also paragraphs in the appendix on the extension of the addition formulas to general angles and on exponential equations. The latter topic is treated too briefly, however.

The text includes answers to three-fourths of the problems. There are four-place tables of trigonometric functions, five-place tables of logarithms of numbers and of trigonometric functions, and a table of squares, cubes, square and cube roots, and reciprocals of numbers 1 to 100.

JOHN R. MAYOR
Science Teaching Improvement Program, AAAS

Man, Culture, and Society. Harry L. Shapiro, Ed. Oxford University Press, New York, 1956. xiii + 380 pp. + plates. Illus. $7.50.

This volume is intended as a basic anthropology for the general reader and as an introductory textbook. The roster of contributors is international in scope. Physical anthropology is represented in the first chapter, "Human beginnings," written by the editor. The next five chapters are devoted to archeology and prehistory. Griffin explains the techniques, while Movius, Childe, and Brew deal with the cultural content of the Old Stone, the New Stone, and Metal Ages, respectively, leaving to Cressman the treatment of "Man in the new world." In the second half of the book there are several general chapters on culture: its nature (Hoebel); its growth (Benedict, edited by Mead); more detailed considerations of dynamics of growth with emphasis on invention (Spier) and on cultural borrowing (Murdock). In addition, the following specific aspects of culture are treated in separate chapters: language and writing (Hoijer); the family (Lévy-Strauss); social groupings (Mandelbaum); religion (Lienhardt); and primitive economics (D. Forde with M. Douglas). The final chapter, "How human society operates," is by Redfield.

The editor is responsible for the over-all planning of the volume, but the contributing specialists have been left free, each to treat in his own way the topic assigned. In addition to some inevitable repetition, there are a few instances of overlapping, which might profitably have been avoided by closer cooperation between editor and authors. But these are minor matters and do not interfere with the aim of presenting the fundamentals to provide an insight into what anthropology is.

A dominant theme is the unique position of man, by virtue of culture, as compared with other creatures. It is expressed in varying contexts and is emphasized even in the chapter by Shapiro, which deals essentially with the biological aspects of man. It is perhaps brought out most fully, both implicitly and explicitly, by Redfield. Moreover, the liberal use that is made throughout of examples from Western civilization makes us aware not only of the differences but also of the similarities between our own particular brand of culture and the great variety of other ways of life.

Limitation of space allows for comment only on a couple of chapters in which the content departs in some respects from that usually found in textbooks. Lévy-Strauss presents an interesting hypothesis to account for the fact that the small, relatively stable monogamic family of father, mother, and children seems to be given greater recognition as such, both among the more primitive peoples and in modern societies, than in what may be called the intermediate levels. Lienhardt, in his thoughtful analysis of the nature of tribal religions, points out a number of the partial and misleading interpretations that have confused our understanding in this area of culture.

REGINA FLANNERY HERZFELD
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Catholic University of America

Soranus' Gynecology. Translated with an introduction by Owsei Temkin with the assistance of Nicholson J. Eastman, Ludwig Edelstein, and Alan F. Guttmacher. Johns Hopkins Press, Baltimore, Md., 1956. xlix + 258 pp. + plates. $5.

Soranus of Ephesus flourished at the time of the Roman Emperors, Trajan (A.D. 98–117) and Hadrian (A.D. 117–138). He was a very great physician who wrote on almost every aspect of medicine but is best known as the leading authority of classical antiquity on obstetrics, gynecology, and pediatrics, in which fields he influenced practice, directly or indirectly, up to the 16th century and beyond. He is also known as one of the leading figures in the sect of the Methodists which evolved from Epicurean atomism through Asclepiades of Prusa to a solidistic, in contrast to a humoral, pathology. This doctrine became little more than a vapid pretense under its later exponents Themison (about 50 B.C.) and Thessalus, physician to the Emperor Nero (A.D. 54–68). Despite the association, Soranus was too great a man to be captured entirely by this empty formalism.

The majority of the writings of Soranus have been lost, and little remains save excerpts preserved or paraphrased by the compilers and encyclopedists, Caelius Aurelianus, Oribasius, Aetius, and Paulus Aeginata. Of his *Gynecology,* despite its great influence, only one corrupt Greek manuscript version of the 15th century survives in a compilation (Parisinus Graecus, 2153). In the middle of this compilation appears a document upon which an unknown has written "Σωρανός ἐστιν," "This is Soranus," and from which the German physician and scholar Friedrich Dietz made a copy, which was published posthumously in 1838. Unfortunately it was not recognized that this version was in itself a compilation, being a mixture of Soranus and Aetius of Amida. An attempt to reconstruct the text was then made by the Dutch physician, Frans Ermerins, whose highly doubtful and arbitrary edition appeared in 1869. Further investigation and collation of manuscripts by the expert philologist Valentin Rose provided, in 1882, a purified text, which was in turn followed by the critical restudy of Johnannes Ilberg, which, after almost 20 years of labor, was published, together with other treatises, by the same author as the fourth volume of the series *Corpus Medicorum Graecorum.*

Although the *Gynecology* of Soranus has been translated into Latin, French, and German, the present work is the first English translation apart from such excerpts and paraphrases as have appeared in the rendering of the works of Caelius Aurelianus, Aetius, Paulus Aeginata, and the like. A very welcome translation it is and excellently done. It is based on Ilberg's text predominantly, is carefully annotated, and is accompanied by an informative and useful introduction, glossary of ancient names, and notes on the contained materia medica. The only regret is that the translation is not accompanied by the Greek text. This is particularly unfortunate when one is dealing with a difficult text that is no longer easy to obtain. There are many subtleties and overlaps of meaning in the terms employed by Greek medical authors on which it is difficult to check without reference to the Greek text. But with the present high costs of publication it is too much to ask for the text, and the scholar must go without.

This translation should be in the hands of every young student, physician, obstetrician, and pediatrician. It is the classical basis of midwifery, and it is filled with interesting observations that will give greater insight into the origin of an art handed down largely by way of that extraordinary popular manual, Rosslin's *Rosengarten,* which has Soranus as a base.

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The Theory of Sound. vols. 1 and 2. John William Strutt and Baron Rayleigh. With a historical introduction by Robert B. Lindsay. Dover, New York, ed. 2, rev. and enl., 1945. 480 pp. and 504 pp. Paper, $3.90 the set.

The classic treatise on those vibrations to which our ears are sensitive, first published in 1877–78 and revised and enlarged by the author in 1894–96, is again available, together with an informative introduction that Robert Bruce Lindsay prepared for the 1945 reissue.

Demographic Yearbook 1955. 7th issue. Special topic: "Population censuses." Statistical Office of the United Nations, New York, 1955. 781 pp. Cloth, $8.50; paper, $7.

The 7th issue of the *Demographic Yearbook,* prepared by the Statistical Office of the United Nations, features population statistics accumulated between the years 1945 and 1954.

Chapter I, "Background to the 1950 censuses of population," discusses the tradition and concept of

population censuses; the main uses of population-census data; growth of national census activity; the role of international agencies in the field of census-taking; and the 1950 censuses and the activities of the United Nations.

Chapter II, "Technical notes on the statistical tables," discusses the sources of data; geographic and ethnic coverage; nomenclature; scope of data and evaluation of quality of data. Part A of this chapter covers area and population; part B is devoted to vital statistics.

Tables included cover population; births; deaths; marriages; divorces; and life-expectancy. Detailed statistics on the age and sex of the populations dealt with account for 152 pages. Two new tables present data on single years of age and on population by size of household. Three tables (100 pages) are devoted to economic characteristics of populations covered.

New Worlds of Modern Science. Leonard Engel, Ed. Dell, New York, 1956. 383 pp. Illus. $0.35.

Leonard Engel's selection of 38 popular essays by noted scientists and journalists is another effort in the important work of explaining recent developments in pure and applied science to the general public. Most of these essays have been published before, either as chapters in more extended works or as contributions to magazines, including *The Scientific Monthly.*

Besides introducing the authors and their topics, the editor notes important advances made since the selections first appeared. A few of the articles are abridged, and some illustrations are omitted. Several of the essays, including the introduction by James R. Killian, Jr., president of Massachusetts Institute of Technology, were prepared especially for this volume.

Books Reviewed in SCIENCE

7 September

Grasslands of the Great Plains, J. E. Weaver and F. W. Albertson (Johnson, Lincoln, Neb.). Reviewed by P. B. Sears.

Psychoanalysis and Psychotherapy, F. Alexander (Norton). Reviewed by R. R. Holt.

Bacterial Anatomy, E. T. C. Spooner and B. A. D. Stocker, Eds. (Cambridge University Press). Reviewed by R. G. E. Murray.

Ultrasonic Engineering with Particular Reference to High Power Applications, A. E. Crawford (Academic; Butterworths). Reviewed by W. L. Nyborg.

The Myology of the Whooping Crane, Grus americana, H. I. Fisher and D. C. Goodman (University of Illinois Press). Reviewed by K. R. Kelson.

The Biology of Senescence, A. Comfort (Rinehart). Reviewed by T. S. Gardner.

14 September

The Moon, H. P. Wilkins and P. Moore (Macmillan). Reviewed by J. Ashbrook.

Handbuch der Laplace-Transformation, vol. II, pt. 1, G. Doetsch (Birkhäuser). Reviewed by T. J. Higgins.

Topological Dynamics, W. H. Gottschalf and G. A. Hedlund (American Mathematical Society). Reviewed by E. E. Floyd.

Histologie und Mikroskopische Anatomie des Menschen, W. Bargmann (Verlag). Reviewed by F. Wassermann.

Science and Information Theory, L. Brillouin (Academic Press). Reviewed by J. Rothstein.

Atoms and Energy, H. W. S. Massey (Philosophical Library). Reviewed by R. D. Myers.

Automata Studies, C. E. Shannon and H. McCarthy (Princeton University Press). Reviewed by E. J. Cogan.

Fluid Models in Geophysics, R. R. Long, Ed. (Government Printing Office). Reviewed by B. Gutenberg.

Gmelins Handbuch der Anorganischen Chemie, vol. 44, *Thorium and Isotopes,* Gmelin Institute, Ed. (Verlag Chemie). Reviewed by R. Gilchrist.

Advances in Catalysis and Related Subjects, vol. VII, W. G. Frankenburg, V. I. Komarewsky, E. K. Rideal, Eds. (Academic). Reviewed by A. C. Zettlemoyer.

21 September

Noradrenaline, U. S. von Euler (Thomas). Reviewed by B. B. Brodie.

The Changing Universe, J. Pfeiffer (Random House). Reviewed by F. K. Edmondson.

New Lives for Old, M. Mead (Morrow). Reviewed by D. N. Michael.

The Pursuit of Science in Revolutionary America, 1735-1789, B. Hindle (University of North Carolina Press). Reviewed by D. J. Struik.

Techniques Générales du Laboratoire de Physique, vol. 1, J. Surugue (Centre National de la Recherche Scientifique). Reviewed by I. Estermann.

28 September

Reactor Shielding Design Manual, T. Rockwell, III, Ed. (Van Nostrand; McGraw-Hill). Reviewed by R. L. Murray.

Floods, W. G. Hoyt and W. B. Langbein (Princeton University Press). Reviewed by A. N. Sayre.

Methods of Biochemical Analysis, vol. III, D. Glick, Ed. (Interscience). Reviewed by J. R. Gillette.

Studies of the Psychology and Behavior of Captive Animals in Zoos and Circuses, H. Hediger (Butterworths). Reviewed by W. M. Mann.

Précis de Géologie, L. Moret (Masson). Reviewed by H. G. Richards.

The Negro Potential, E. Ginzberg (Columbia University Press). Reviewed by H. Branson.

New Books

Report of the Special Committee on the Federal Loyalty-Security Program of the Association of the Bar of the City of New York. Dodd, Mead, New York, 1956. 301 pp. $5.

Geology and Ourselves. F. H. Edmunds. Philosophical Library, New York, 1956. 256 pp. $10.

Die Pathologie des Kindlichen Pankreas. Gerhard Seifert. Thieme, Leipzig, 1956. 151 pp. DM. 52.

Determination of Organic Compounds. K. G. Stone. McGraw-Hill, New York, 1956. 233 pp. $5.

On the Early Development of Mind. Selected papers on psycho-analysis. vol. I. Edward Glover. International Universities Press, New York, 1956. 483 pp. $7.50.

Child Development and Personality. Paul H. Mussen and John J. Conger. Harper, New York, 1956. 569 pp. $6.

Taboo. Franz Steiner. Philosophical Library, New York, 1956.

Earth Satellites as Research Vehicles. Proceedings of the symposium held 18 Apr. 1956 at the Franklin Institute in Philadelphia. Monograph No. 2. Journal of the Franklin Institute, Philadelphia, Pa., 1956. 115 pp. $2.50.

Essentials in Problem Solving. Zuce Kogan. Arco, New York, 1956. 119 pp. $3.

CIBA Foundation Symposium on Extrasensory Perception. G. E. W. Wolstenholme and Elaine C. P. Millar. Little, Brown, Boston, 1956. 240 pp. $6.

Science and Civilisation in China. vol. 2. *History of Scientific Thought.* Joseph Needham. Wang Ling, research assistant. Cambridge University Press, New York 22, 1956. 696 pp. $14.50.

Numerical Analysis. Proceedings of symposia in applied mathematics. vol. VI. John H. Curtiss, Ed. McGraw-Hill, New York, 1956. 303 pp. $9.75.

Chemistry and Uses of Pesticides. E. R. de Ong. Reinhold, New York; Chapman & Hall, London, ed. 2, 1956. 334 pp. $8.75.

Nuclear Fuels. David H. Gurinsky and G. J. Dienes. Van Nostrand, Princeton, N.J., 1956. 364 pp. $7.50.

Atoms and Energy. H. S. W. Massey. Philosophical Library, New York, 1956. 174 pp. $4.75.

Anatomy of the Honey Bee. R. E. Snodgrass. Comstock Division of Cornell University Press, Ithaca, New York, 1956. 334 pp. $6.

Handbook of South American Geology. An explanation of the geologic map of South America. Geological Society of America Mem. 65. William F. Jenks, Ed. Geological Society of America, New York, 1956. 378 pp.

Epilepsy and the Law. A proposal for legal reform in the light of medical progress. Roscoe L. Barrow and Howard D. Fabing. Hoeber-Harper, New York, 1956. 177 pp. $5.50.

Facing the Atomic Future. E. W. Titterton. Macmillan, London, 1956 (order from St Martin's Press, New York). 379 pp. $5.

The Trickster. A study in American Indian mythology. Paul Radin. Philosophical Library, New York, 1956. 211 pp. $6.

Television Engineering, Principles and Practice. vol. II, *Video-Frequency Amplification.* BBC Engineering Training Manuals. S. W. Amos and D. C. Birkinshaw. Iliffe, London; Philosophical Library, New York, 1956. 270 pp. $15.

Abacs or Nomograms. An introduction to their theory and construction illustrated by examples from engineering and physics. A. Giet. Trans. and revised by J. W. Head and D. H. Phippen. Iliffe, London; Philosophical Library, New York, 1956. 225 pp. $12.

Vom Unbelebten zum Lebendigen. Eine Ringvorlesung an der Universitat Munster (Westf.) Enke, Stuttgart, 1956. 273 pp.

Minimum Weight Analysis of Compression Structures. George Gerard. New York University Press, New York, 1956. 194 pp. $6.

United States Army in World War II. The Technical Services. *The Medical Department: Hospitalization and Evacuation, Zone of Interior.* Charles McKittrick Smith. Office of the Chief of Military History, Department of the Army, Washington, D.C., 1956 (order from Supt. of Documents, GPO, Washington 25). 503 pp. $4.

Structural Geology. L. U. De Sitter. McGraw-Hill, New York, 1956. 552 pp. $11.

The Petroleum Refinery Engineer's Handbook. J. F. Strachan. Philosophical Library, New York, 1956. 168 pp. $15.

Polysaccharides in Biology. Transactions of the First Conference, 27–29 Apr. 1955, Princeton, N.J. Georg F. Springer, Ed. 271 pp. Illus. $5. ***Neuropharmacology.*** Transactions of the Second Conference, 25–27 May 1955, Princeton, N.J. Harold A. Abramson, Ed. 328 pp. $4.25. Josiah Macy, Jr. Foundation, New York, 1956.

Valency and Molecular Structure. E. Cartmell and G. W. A. Fowles. Academic Press, New York; Butterworths, London, 1956. 256 pp. $5.80.

The Generation of Electricity by Wind Power. E. W. Golding. Philosophical Library, New York, 1956. 318 pp. $12.

Muscle Testing. Techniques of manual examination. Lucille Daniels, Marian Williams, Catherine Worthingham. Saunders, Philadelphia, ed. 2, 1956. 176 pp.

Plants in Action. A laboratory manual of plant physiology. Leonard Machlis and John G. Torrey. Freeman, San Francisco, 1956. 282 pp.

Annual Epidemiological and Vital Statistics, 1953. pt. 1, *Vital Statistics and Causes of Death*; pt. 2, *Cases of and Deaths from Notifiable Diseases.* World Health Organization, Geneva, 1956. 571 pp. $10.

The Chemistry and Technology of Waxes. Albin H. Warth. Reinhold, New York; Chapman & Hall, London, ed. 2, 1956. 940 pp. $18.

Varieties of Human Value. Charles Morris. University of Chicago Press, Chicago, Ill., 1956. 209 pp. $5.

Elementary Crystallography. M. J. Buerger. Wiley, New York; Chapman & Hall, London, 1956. 528 pp. $8.75.

Cryptanalysis. A study of ciphers and their solution. Helen Fouche Gaines. Dover, New York, 1956. Paper, $1.95.

The American Experiences of Swedish Students. Retrospect and aftermath. Franklin D. Scott. University of Minnesota Press, Minneapolis, 1956. 129 pp. $3.

Exploring the Deep Pacific. Helen Raitt. Norton, New York, 1956. 272 pp. $3.75.

Photosynthesis and Related Processes. vol. II, pt. 2, *Kinetics of Photosynthesis.* Eugene I. Rabinowitch. Interscience, New York, 1956. 877 pp. $18.50.

Measurements of Mind and Matter. G. W. Scott Blair. Philosophical Library, New York, 1956. 115 pp. $4.50.

California and the Southwest. Clifford M. Zierer, Ed. Wiley, New York; Chapman & Hall, London, 1956. 376 pp. $11.25.

Wheat-Climate Relationships and the Use of Phenology in Ascertaining the Thermal and Photo-Thermal Requirements of Wheat. Based on data of North America and of some thermally analogous areas of North America in the Soviet Union and Finland. M. Y. Nuttonson. American Inst. of Crop Ecology, Washington, 1956. 388 pp.

Immigrants and Their Children, 1850–1950. E. P. Hutchinson for the Social Science Research Council in cooperation with the Bureau of the Census. Wiley, New York; Chapman & Hall, London, 1956. 391 pp. $6.50.

An Introduction to Scientific German. J. Henry Wild. Oxford University Press, New York, ed. 2, 1956. 177 pp.

Nuclear Explosions and Their Effects. Foreword by Jawaharlal Nehru. Publ. Div., Ministry of Information & Broadcasting, Government of India, Delhi, 1956. 184 pp. $2.

Chemical Engineering Kinetics. J. M. Smith. McGraw-Hill, New York, 1956. 402 pp. $8.

Minerals and the Microscope. H. G. Smith. Revised by M. K. Wells. Macmillan, New York, rev. ed., 1956. 148 pp. $3.

Transport and Accumulation in Biological Systems. E. J. Harris. Academic Press, New York; Butterworths, London, 1956. 291 pp. $7.80.

Fertilization. Lord Rothschild. Methuen, London; Wiley, New York, 1956. 170 pp. $3.50.

Evolution and Classification of the Mountain Caddisflies. Herbert H. Ross. University of Illinois Press, Urbana, 1956. 213 pp. $6.

Civil Air Regulations and Flight Standards for Pilots. Associated Aeronautical Staff. AERO, Los Angeles 26, Calif., 1956. 138 pp. $2.

Common Exotic Trees of South Florida (Dicotyledons). Mary Franklin Barrett. University of Florida Press, Gainesville, 1956. 414 pp. $8.50.

The Menninger Story. Walker Winslow. Doubleday, Garden City, N.Y., 1956. 350 pp. $5.

Weather Analysis and Forecasting. vol. II, *Weather and Weather Systems.* Sverre Petterssen. McGraw-Hill, New York, ed. 2, 1956. 266 pp. $6.

Proceedings of the Third Berkeley Symposium on Mathematical Statistics and Probability. Held at the Statistical Laboratory, University of California, December 1954; July and August 1955. vol. IV, *Contributions to Biology and Problems of Health.* Jerzy Neyman, Ed. University of California Press, Berkeley, 1956. 179 pp. $5.75.

Proceedings of the Third Berkeley Symposium on Mathematical Statistics and Probability. Held at the Statistical Laboratory, University of California, December 1954; July and August 1955. vol. V, *Contributions to Econometrics, Industrial Research, and Psychometry.* Jerzy Neyman, Ed. University of California Press, Berkeley, 1956. 184 pp. $5.75.

White Collar. The American middle classes. C. Wright Mills. Oxford University Press, New York, 1956. 377 pp. Paper, $1.75.

The Theory of Groups. vols. I and II. A. G. Kurosh. Translated and edited by K. A. Hirsch. Chelsea, New York, 1955. 272 pp.; 308 pp. $4.95 each.

Diseases of Fruit Crops. Harry W. Anderson. McGraw-Hill, New York, 1956. 501 pp. $8.50.

Electric Circuit Theory and Operational Calculus. John R. Carson. Chelsea, New York, ed. 2, 1953. 197 pp. Paper, $1.88.

Gaseous Nebulae. vol. 3 of *The International Astrophysics Series.* L. H. Aller. Wiley, New York, 1956. 322 pp. $11.

Sodium, Its Manufacture, Properties and Uses. Marshall Sittig. With a chapter on "The physical and thermodynamic properties of sodium" by George Wm. Thomson and Edward Garelis. Reinhold, New York; Chapman & Hall, London, 1956. 529 pp. $12.50.

Dead Towns and Living Men. Leonard Woolley. Philosophical Library, New York, 1956. 220 pp. $6.

A Study of Thinking. Jerome S. Bruner, Jacqueline J. Goodnow, George A. Austin. Wiley, New York; Chapman & Hall, London, 1956. 330 pp. $5.50.

Linear Transient Analysis. vol. II, *Two-Terminal-Pairs Networks Transmission Lines.* Ernst Weber. Wiley, New York; Chapman & Hall, London, 1956. 452 pp. $10.50.

The Structure of Wood. F. W. Jane. Macmillan, New York, 1956. 427 pp. $9.50.

In Search of Adam. The story of man's quest for the truth about his earliest ancestors. Herbert Wendt. Trans. by James Cleugh. Houghton Mifflin, Boston, Mass., 1956. 540 pp. $6.50.

Hurricanes. Their nature and history, particularly those of the West Indies and the Southern coasts of the United States. Ivan Ray Tannehill. Princeton University Press, Princeton, N.J., ed. 9, 1956. 308 pp. $4.50.

Chazyan and Related Brachiopods. pt. 1, text; pt. 2, plates. G. Arthur Cooper. Smithsonian Institution, Washington, 1956. 1263 pp. 269 plates.

Mandl's Television Servicing. Matthew Mandl. Macmillan, New York, rev. ed., 1956. 460 pp. $6.50.

Physics, Psychology and Medicine. A methodological essay. J. H. Woodger. Cambridge University Press, New York, 1956. 146 pp. $1.75.

The Zoological Record. vol. 90. Records of zoological literature relating chiefly to the year 1953. G. Burder Stratton, Ed. Zoological Soc. of London, London, 1956. 19 sections. 1750 pp.

Man's Role in Changing the Face of the Earth. William L. Thomas, Jr. University of Chicago, Chicago, Ill., 1956. 1193 pp. $12.50.

Protozoologie. Karl G. Grell. Springer, Berlin, 1956. 284 pp. DM. 59.

Reading Improvement for Adults. Paul D. Leedy. McGraw-Hill, New York, 1956. 456 pp. $5.95.

The Potentials about a Point Electrode and Apparent Resistivity Curves for a Two-, Three-, and Four-Layer Earth. Harold M. Mooney and W. W. Wetzel. University of Minnesota Press, Minneapolis, 1956. 146 pp. + graphs. Text, $4.50; complete set, $18.

The Dîné: Origin Myths of the Navaho Indians. Smithsonian Institution Bur. of American Ethnology Bull. 163. Aileen O'Bryan. U.S. Government Printing Office, Washington 25, D.C., 1956. 187 pp. $1.75.

Engineering Mechanics. S. Timoshenko and D. H. Young. McGraw-Hill, New York, ed. 4, 1956. 546 pp. $7.50.

Musical Acoustics. Charles A. Culver. McGraw-Hill, New York, ed. 4, 1956. 305 pp. $6.

(*Continued on page viii*)

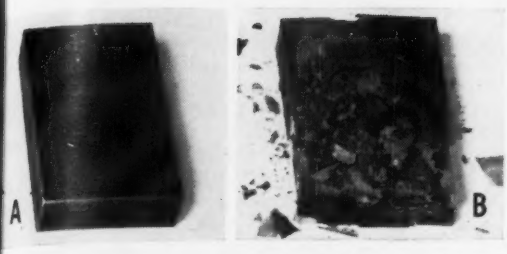

Photo A) Kentanium shows only slight oxidation after test and is good for many more hours' exposure at 2000°F. (Photo B) Hard nickel-chromium (35%) alloy is badly oxidized and began to disintegrate during test.

KENTANIUM* unharmed at 2000° F while heat-resistant nickel-chrome alloy disintegrates

Exceptional resistance to oxidation, combined with great strength at very high temperatures, are characteristics of Kentanium, a titanium carbide composition. Here's proof.

A square of K161B Kentanium and a similar square of a well-known, heat-resistant 35 chromium-15 nickel alloy were exposed for 120 hours in an unsealed muffle furnace heated to 2000°F. The accompanying photographs vividly show how each piece was affected. While Kentanium is still good for hours of exposure at high temperatures, the nickel-chrome alloy has oxidized badly and has begun to disintegrate.

This demonstration suggests how well Kentanium will perform in such applications as furnace parts, heat-treating fixtures, quench guide rings, turbine blades, nozzle vanes, bushings and other parts where strength at high temperature, plus high resistance to oxidation, are factors.

Parts illustrated at the right are typical applications of Kentanium. The Kentanium series represents only a part of Kennametal's wide range of hard carbide compositions that are helping designers who require metals offering high resistance to abrasion, deflection, deformation, impact or corrosion. Perhaps one or more of these Kennametal compositions will help you get your idea off the drawing board into production. These materials are described and many applications discussed in two booklets: B-111-A—"Characteristics of Kennametal," and B-222—"Designing with Kennametal."

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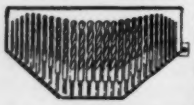

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